FOUNDATIONS OF CARTOGRAPHIC METHODOLOGY

DISSEMINATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

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Approved by:
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PREFACE

The study of Cartographic methodology until recent years has been largely concerned with the substantive phases. The equally important visual aspects have received scant and inconsistent attention. There are a number of reasons why this has been the case, but probably none has been more influential than the fact that until recently the profession of cartography has had few members. In their minds the importance of map data has far overshadowed its presentation media. Those cartographers who contemplated questions of presentation approached their problems with little if any background in the principles of design and the traditions of art. Yet they chose to consider themselves artists with full freedom to create whatever their limited talents allowed. Certainly, prior to 1850 no cartographer had shown any broad recognition of the essential relationship between data and technique.

During the 19th century and after, cartography was presented with technical and scientific advances in the fields of mechanical reproduction, color sensation, psychological aesthetics, and expanding media of all kinds. The thrusting of these advances upon the field (most of them were dis-
covered or invented by non-cartographers) caused great confusion and, by and large, cartography has not kept pace. Much of the reason for its lag is to be found in the economic position of the profession. Like most professions, the number and quality of its members varies according to the amount of support, financial and otherwise, it can command. There have been few workers in the field and even fewer who might be called technical experts. Most persons who qualified as cartographers were so busy making a living and working with geographic data that the time and opportunity for research did not present itself. Similarly, in the commercial field effort was directed primarily at keeping abreast of the rapidly expanding knowledge of the mappable earth. So long as the competitive requirements could be met with new or different data, technical advance was unnecessary.

War, as might be expected, provides a great stimulus to cartography. Subsequent to the first World War and during and after the second World War much thought was given to technical advances. The majority of these technical advances have had to do with the mechanical aspects of production. During the past twenty-five years, however, great strides have been made in the fields of design and visual evaluation, because of the growth of commercial art in advertising and of psychological and experimental investigation in aesthetics. It is only natural therefore that the broader use of maps
resulted in the questioning of the older conventions and procedures.

The writer was made acutely aware of the limitations of conventional presentation techniques in his work of directing the cartography of the Office of Strategic Services from 1941 to 1946. His experience clearly showed that the creation of specialty maps (maps for specific presentations) was as much a problem in design as it was a problem in substantive research, and that the artist and commercial art were better fitted to solve the design problem than was the conventionally trained cartographer. Unfortunately bases for the evaluation of the visual presentation techniques were either lacking or if existing, were so aimed at specific undertakings, such as advertising, as to be essentially unusable by the cartographer. Accordingly the writer requested and received approval from the Department of Geography at the Ohio State University to embark upon a study of the bases of cartographic methodology for the Ph. D. dissertation.

Because of the importance of specialty cartography as a tool of the social sciences application was made to the Social Science Research Council for financial assistance. A stipend was granted which made it possible to carry on part of the research during the two summers following the writer's resignation from the State Department in January 1946.

Arthur H. Robinson
CHAPTER I

FOUNDATIONS OF CARTOGRAPHIC METHODOLOGY

Introduction

In former times when the use of maps was largely limited to specialists such as navigators, surveyors, military planners, and the like, the preparation of their maps was concerned with problems of fact. The story of the development of cartography from its beginnings is essentially the story of exploration, survey, and the mathematics of projections. Only in the last few centuries have major advances been made in the techniques of cartography. The majority of these advances, like the contour and hachure, have had to do with fundamental intellectual problems of the presentation of quantitative fact. Accuracy is, of course, the first objective of any scientific activity; but when presentations of factual materials become widely used and their techniques widely utilized by those not especially familiar with the facts, the manner of presentation becomes of first significance. This is of more than ordinary importance with respect to cartography and approaches critical consequence when one deals with the specialty map, the map which treats but a few categories of data. The navigator and engineer are primarily concerned with spatial
data of a precise, numerical nature, and for these data, charts, topographic maps, and the language of mathematics, are reasonably adequate means for their display. The same cannot be said for the social scientist (nor for the average man) who, on the other hand, is commonly concerned with less precisely definable data, relationships, and concepts.

Maps in the social sciences as well as their written terminology deal more with the qualitative and interpretive aspects of investigation and knowledge. The vehicles for presenting qualitative materials must be capable of recreating in the mind of the reader, so far as possible, precisely the intended intellectual meanings and interpretations. It is relatively easy to accomplish this when language is the medium, since there are generally accepted standards and definitions for its use. Words are merely intellectual ideas graphically presented; but, unlike most visual symbol forms, they pass through the eye to the brain without occasioning major visual stimuli. There are, to be sure, significant variations in the readability of type faces, point sizes, and page layouts but, by and large, long usage has tended to submerge these to such an extent that it is doubtful if any significantly erroneous intellectual reactions could be blamed on them. In cartography, on the other hand, the graphic techniques and media are legion, and the possibilities of arrangement are so tremendous that the inexpert
reader, when viewing qualitative and even some quantitative data, cannot help but receive unconsciously from the unfamiliar visual forms many sensory impressions in addition to the intellectual concepts intended by the cartographer.

Any map is a complex visual thing for, like any other graphic presentation, all its shapes have both a visual as well as an intellectual relationship to one another. Anything existing within the neat or trim lines may be described as a series of related intellectual concepts represented by visual media. In some cases the visual raiment is sufficiently characteristic or well known that one is able unconsciously to disregard the visual stimuli and see and recognize clearly the intellectual concept. In other cases the media acts as a covering like a suit of armor and so obscures the intellectual thought that the only way to determine its identity is through reference to a legend or a key. Many times the eye and the mind instinctively makes guesses concerning the nature of the things thus visually displayed regardless of the care on the part of the viewer to accept only known facts. This happens often since, either because of prior experience or because of some unconscious physiological or psychological stimulus, the mind and the untrained eye do not ordinarily distinguish between intellectual and visual stimuli. Indeed, for many people it is next to impossible, for the major part of know-
ledge comes to all of us through our eyes, and it is only natural to confuse visual and intellectual factors. Seeing is believing!

The existence of confusion between visual and intellectual factors on maps is of major importance in a number of somewhat interrelated ways. Probably the most important concerns the systematic control of legibility with respect to the various components of a map. However neatly a map may have been drawn it may be counted as wasted effort if the various parts, lines, lettering, and symbols are selected and arranged in such a way that they are not readily seen. Nearly as important is the objective of limiting the use of techniques and media which over-stimulate or tire the eye. For example, it is as unfortunate as it is surprising that the majority of cartographers do not seem to realize that closely spaced parallel lines are fatiguing to the eye. (Figs. 1, 2) Less significant than either of the above, but nevertheless important, is the use of media and techniques whose visual effects enhance or at least parallel the intellectual concepts being portrayed. For example, if blue rivers do not "lie down" in their colored valleys, because of the cartographer having ignored the stereoscopic effects of colors, it will create confusion between what the eye sees and what the mind knows. Although the cartographically untrained map reader may not be aware
Fig. 1. Parallel lines at their extreme.
A drawing near the extreme of eye fatigue.
Fig. 2. Parallel lines in use. An example of the use of this fatiguing technique. The patterns represent terrain types. (From George B. Cressey; Asia's Lands and Peoples, New York and London, 1944, p. 156).

of such crudity, there will be a certain amount of rebellion against such a visual-intellectual conflict which cannot fail to affect his receipt of information from the map and general attitude toward the map.

Heretofore most cartography has been accomplished with insufficient regard for the immediate purposes aimed at. This disregard for the direct functions of cartographic techniques has been accompanied by undue dependence upon
convention and custom accompanied in many instances by absurd rationalization. Logical foundations for many of these conventions are commonly lacking. For example, Eckert asserts that brown is the best color for terrain, contours, etc., since "The fundamental color of the soil is brown..." With few exceptions current visual cartographic convention, custom, and procedure are based neither on experiment, nor on visual logic. The unsystematic visual methodology is further confused by oft-stated assertions concerning the aesthetic aspects of this creative field which tend to make the choice of technique and media a matter of individual temperament and caprice. Needless to

1Max Eckert-Greifendorff: Kartographie, Berlin, 1939, p. 41. Eckert goes on to say "... as is especially evident in freshly tilled soil in the spring." This is the kind of "logic" which has tied cartography to convention. If his "logic" be analyzed he is actually claiming that the color for terrain, isobases, etc., should be based solely on the B horizon of middle latitude humid forest and steppe land soils. In any case it is difficult to see why contour color should have anything to do with soil color. Contours lie on the ground and the surface of most soils is either a) black or nearly so (and covered with green vegetation), or b) red (and covered with green vegetation), or c) if visible, as in arid regions, a color ranging from grays through degraded yellows. Large areas of the earth have no soil cover. How much better it would be to determine contour color on the basis of a) maximum transparency with solid "body", b) preciseness of definition, c) degree of "continuous tone" produced by lines in juxtaposition, d) lack of disharmony with other contemplated color use, etc. Objective investigation may point to brown as the best color, but not because it is the color of "freshly tilled soil in the spring."
say, it is unfortunate that the methodology of one of the most important presentation techniques of the social and physical sciences is so poorly understood.

Functionalism in Cartography

The chief purpose of a map is to portray graphically some distributive fact or group of facts. Any more limiting statement is apt to be misleading since, as Wright has phrased it, "So many are the kinds and uses of maps that it would be futile to attempt to catalogue them." As Speier points out,

"Maps are not confined to the representation of a given state of affairs. They can be drawn to symbolize changes, or as blueprints of the future. They may make certain traits or properties of the world they depict more intelligible -- or may distort or deny them. Instead of unknown relationships of facts they may reveal policies or illustrate doctrines. They may give information but they may also plead."

The above applies almost equally well to the written language. Considering the wide use of maps and their importance as media for portraying scientific fact it is indeed surprising that there has been relatively so little

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written on the subject of cartographic methodology as such. Davis complains that "Maps are . . . indispensible . . . but they are inarticulate, and their silence seems to have affected their makers", and "It is as if their expertness in the graphic expression of facts were accompanied by an atrophy of the faculty of verbal expression following its disuse". The reference to expertness may be open to question, but there can be no argument about the lack of critical written material on the methodological aspects of cartography. If most small scale maps are prepared with specific objectives in mind, it could be reasonably expected that like any other practical creative field, such as architecture or advertising, there would exist a body of principles and laws based on experience, experimental research, or logic which would govern the employment of the various structural materials toward the utilitarian end. By reference to these principles one could, within the bounds of controversial interpretation, arrive at fairly accurate evaluations of the effectiveness with which the techniques and media accomplish their purpose.

The drawing of a parallel between cartography and architecture is not difficult. Each lies in the field of the "practical arts"; each is older than history; and each, since its beginnings, has been more or less under the control of

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its consumers. The "principles" of architectural and cartographic creation have been based on convention, whim, and in many cases on well meant but ill-founded judgment. In addition, the majority of workers in each field has generally concealed functional inadequacies beneath the guise of artistry, which has been a safeguard only because of the general lack of objective standards of practical artistry.

It is interesting and informative to draw such a parallel since the past generation has witnessed what amounts to a revolution in the field of architecture. Modern building, within the limits of reactionary opposition, has become functional. It is now accepted that a structure will be planned and built according to the needs of its future users. It is not expected that the inhabitants will conform to the structure. Function provides the basis for the design. A similar revolution appears long overdue in cartography. The development of design principles based on objective visual tests, experience, and logic, the pursuit of research in the physiological and psychological effects of color, investigations in perceptibility and readability in typography, and particularly the more widespread use of maps leads to the conclusion that such a movement in cartography cannot fail to materialize.

There are indications in the literature that such a functional approach is already receiving attention. In 1933
the National Society for the Study of Education devoted its Yearbook to geography and one chapter to map standards. This relatively unpretentious statement may well be the first American appeal for a truly functional approach to cartographic methodology. It specifically asks for investigations in the visual standards of maps and suggests as worthy subjects for research such topics as legibility, psychological effects of color, and clarity. Throughout the entire chapter the need for simplicity and the wider use of the specialty map is stressed. Ten years later, during the war, a large number of cartographers in government service realized the visual inadequacies of conventional small scale cartography, and devoted considerable thought to the subject of functionalism. A Committee on Cartography of the American Society for Professional Geographers in drawing on that recent experience for the benefit of the academic aspects of the subject summarized the conclusions by pointing out that: "Greatest emphasis in a course on cartography should be placed on map design and planning as related to the purpose of the map. . . ."


Although geographers and cartographers are prone to judge maps the major portion of such functional evaluation is made, not in terms of the visual aspects, but in terms of the geographic content. Even Marschner, in his plea for inclusion of some of the projectional elements of structure as components of function illustrates this relatively narrow attitude when he points out that "geographers and economists... are dependent upon a motley assortment of maps that in most cases are, neither in content nor in structure, functionally conceived to take care of their particular needs". It may be presumed as self evident that content is merely an obvious functional aspect of a map, and that neither its determination nor its evaluation is a matter of methodology. If we assume that the content of a map is appropriate to its purpose there remains, however, the evaluation of the visual means utilized to convey that content. These graphic techniques and the logic which binds them to their function and determines their utilization constitute cartographic methodology.

Aesthetics in Cartography

When one searches within cartographic literature for bases with which to evaluate visual cartographic methodology we find it to be practically devoid of principles. But more disconcerting is the unchallenged assumption that effective methodologic procedure and evaluation is based in part on some subjective artistic or aesthetic sense on the part of the cartographer and map reader. For example, Raisz claims that the "effective use of lines or colors... requires artistic judgment", and Wright explains that the suitability of a symbol "depends on the map maker's taste and sense of harmony". Throughout the literature there are numerous similar assertions regarding the subjective aesthetic and artistic content which are unaccompanied by justification or logical explanation.

There is also a considerable tendency to define the subject as a kind of amalgamation or meeting place of science and art. This is exemplified by Eckert. It is difficult to appreciate this point of view although Eckert strongly supports it. He recognizes the interplay of technique and content, but does not distinguish between the two. He pleads for artistic imagination and intuition in carto-

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graphic portrayal and claims that the interaction of such talents with scientific geography produces the aesthetic map. Even if one were to grant that the arousing of aesthetic responses were part of cartography, this does not argue for investigations into the visual or intellectual reactions to techniques, but rather puts a premium on talent and temperament. There is no question about the importance of imagination and new ideas, but it is equally important that significant processes be objectively investigated, whether it be the visual consumption of a graphic technique or a process in geomorphology. In order to understand the degree to which art enters into cartography it is necessary to examine some of the fundamentals of each in order that the logic does not become simply a matter of semantics. It can perhaps best be approached by a comparison of the aims, techniques involved, and the results accomplished by each activity.

Most scientific cartography is concerned with the addition to and the dissemination of our fund of spatial knowledge. The aim of visual art is more difficult to express. Generally speaking it may be said to have two basic aims,

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one of which is to provide aesthetic pleasure through visual (sensuous) stimuli. In many instances, and especially significant in cartography, this has taken the relatively crude form of ornamentation. This, so far as cartography is concerned, may well be considered a low form of such art based on the uncritical and popular conception that anything graphic that is difficult is thereby artistic. Even assuming (and it is a difficult assumption) that the fancy borders (Fig. 3), ornamental cartouches (Fig. 4), curvaceous lettering, and other decorative features (Fig. 5), so common in older maps, and still not uncommon, is a source of pleasure to a reader it does not seem illogical to suggest that such "art" does not add to the functional quality of the map. On the contrary, it may actually detract from it for the attention may be thus directed to these components when it should be concerned with the data presented for consumption. As with ornamentation so also the use of color on maps has been held as irrefutable proof that there is aesthetic art in cartography. With respect to the use

11 The discussion of aesthetics is here abbreviated as much as possible since there does not seem to be much conflict concerning the basic concepts that a) it is aimed toward sensuous apprehension and b) the aims of "art" are varied but include beauty and instruction. Although the author arrived at this view independently it is essentially that summarized in G. W. F. Hegel, The Philosophy of Fine Art, (Translated by F. P. B. Osmaston, London, 1920), Vol. 1, pp. 1-122.

12 Cf. Max Eckert-Greifendorff: op. cit., p. 27.

13 Ibid., p. 31 ff. Yet elsewhere Eckert has made a
Fig. 3. Ornamentation. An example of excessive ornamentation involving scrolls and decorative borders. Note that the checkered border of the inset bears no relation to the earth grid. The original is highly colored. (From The Cartographic Dept. of the National Geographic Society: The World Map, Washington, 1943.)
Fig. 4. Ornamental cartouche. Mercator's map of 1569. (From Charles O. Paullin: Atlas of the Historical Geography of the United States, (John K. Wright, Ed.), Washington and New York, 1932, Plate 15.)
of color, ornamentation and other assumed elements of art there seems to be considerable confusion between the creative motives involved and the effects produced. The fact that there is a "joy of creation" in map-making is no argument that there is art in cartography, for there is similar pleasure associated with any creative effort whether it be painting, composition of music, or gardening. A map, being a functional scientific object, should be intended primarily to stimulate the intellectual aspects of our mental processes. The fact that it uses visual media to do so is beside the point. If the final composition also appears "beautiful", that aspect is quite apart from its primary function and may, as previously pointed out, detract from its effectiveness as a map, since the aesthetic response may take precedence over or interfere with the intellectual response. That is not meant to imply the extreme, that something created for practical purposes must therefore not be pleasurable. Certainly any job, well done, especially a creative undertaking provides pleasure both to its creator and observer. What is meant, on the contrary, is that any aesthetic stimuli which may be included in a map should be incorporated consciously and with full realization of its effect on the other visual material.

Searching analysis of the color research carried on around the turn of the century by Feucker, Bruckner, et al. and approaches it from a strictly objective point of view.
The other aspect of art, the art which attempts to awaken various responses not necessarily of beauty, received little attention in cartography until the use of maps for propaganda purposes came into favor. It is difficult and perhaps unsatisfactory to attempt to separate the two aspects of art from the point of view of motivation because the techniques of the two are essentially similar, and certainly the motives are commonly combined or confused. In non-aesthetic art the aim may be any of a multitude of possibilities but a basic characteristic is the attempt to construct visual stimuli which will produce desired mental responses. It is a well known fact that certain colors, shape combinations, and line relationships, produce predictable responses including intellectual connotations such as simplicity, confusion, density, rhythm, and balance. Figures six and seven illustrate propaganda use of design, the former suggesting excessive density and the latter suggesting loss from previous "ownership". Recently two authors have considered its manifestation in cartography and, probably as a result of reaction to its use for propaganda purposes, have taken a negative approach. Wright confuses the visual and intellectual, but Speier acknowledges that *... size, color, and design, can be made to serve propa-

14 John K. Wright: op. cit., and H. Speier, op. cit.
Fig. 6. Propaganda map "showing" the percent of population which is Jewish. An example of the insidious use of maps for propaganda by the Germans. Note that Poland, recently overrun by the Germans at the time of publication, is shown at the extreme of the value range although the maximum density is only nine per cent. Note also the use of the Mercator projection and the shading of the entire areas of Canada and the U.S.S.R. (From Walther Jantzen: Geopolitik in Kartenbild: Die Juden, Frankfurt am Main, No date - about 1940, Fig. 20.)
Fig. 7. Propaganda map suggesting by captions (German Bohemia!) and by boundary position and solidity of blacks the previous "ownership" of "lost" territories.  
(From Rudolf zu der Luth: Wehrwissenschaftlichen Atlas, Wien, 1933, p. 8.)
15 Gandistic ends." There can be little doubt that if the use of visual techniques to stimulate predictable responses is accepted as within the field of art, then cartography includes artistic techniques. These techniques and media may and should be utilized in the attempt to satisfy the functional requirements of a map, for a map is a graphic thing that cannot be made visually sterile. However, the employment of the artistic techniques referred to should not be based on the cartographer's "artistic judgment", "taste", or "sense of harmony". They are techniques to accomplish specific purposes and should be utilized according to well founded methodologic principles.

Conventionalism in Cartography

Like most of the other "practical arts" cartography has been greatly influenced by the force of convention. Until the last century or so this powerful influence was sufficient, considering the technical limitations, to maintain the profession in good standing with the other arts. As the technical horizon widened, however, convention only gradually relinquished its hold on cartography. Notwithstanding, there were many changes (the cartography of 1910 is very different from that of 1810) yet the power of con-

vention had not greatly decreased. The force simply transferred itself to other technical phases. The advances of the past one hundred years have been enormous but, generally speaking, convention has merely replaced convention. Only in recent years has searching analysis and logic been applied to the field.

Examples are many. Perhaps the most widely publicized in recent years is the general use of the Mercator projection. This projection, designed for a specific purpose, navigation, has been regularly and indiscriminately used although many other projections more suitable for general purposes had long been known. Only because of our recent so-called "entrance into the air age", and the vituperation against the Mercator accompanying the move, has this projection declined in popularity. It is interesting to note that, as has been the case in the past, the conventionalism, rather than disappearing, seems to be in the process of being transferred, this time to the polar aspects of the azimuthal projections.

Many conventions are logical or stand functional analysis. In this category may be placed many of the techniques of symbolism such as dots, circles, or squares for cities; the pictorial kinds of symbols such as hatched lines for railroads; dot-dash lines for political boundaries; and the innumerable conventional signs on topographic maps. They constitute a kind of cartographic shorthand and so long as
they are employed with proper regard for their effect on the overall design of the map they are adequate for indicating character and location. The importance of the visual functional evaluation of spatial symbols is well illustrated by Wright who points out that although "tiny men, or ears of corn, or cows . . . in a sense . . . may be in better "harmony" with the things they represent than flat colors or shading would be, they may also be out of harmony with the purpose of the map if that purpose is to give a clear and clean-cut concept." (Fig. 3).

Some conventions are justified on the grounds that they have been tested by time and found good. All too often however they have been tested only by their makers and basic analysis of their visual effects and logic have been lacking. The prime example of such a convention in cartography is the practice of presenting hypsometric "layers" somewhat according to the spectrum, that is with green for the lower altitudes ranging upward through the yellows and reds even to violet. This system of progression has even been given international approval for it was chosen as the basis of the system of representing hypsometric data on the International Map. Its champions point to the fact that most people are familiar with the system and thus it "has been found by

16 Wright: *Map Makers are Human*, op. cit., p. 542.
Fig. 8. Pictorial symbols on a scientific map. Note the ornamental cartouche. (From Erwin Raisz: General Cartography, New York and London, 1938, p. 66.)
experiment and experience to give a graphic visual impression of relative altitudes. Similar rationalization opposes most proposals of change. When analyzed the convention has only its traditional usage for justification. The spectrum bears no relation to altitude except possibly in areas where the lowlands are covered with vegetation and it is likely that the reverse is too common to make it a valid generalization. Even more important is the visual fact that the colors of the spectrum bear no apparent relation to one another so far as the eye is concerned. Actually their lack of relation is much more significant in vision. The wide variation in brightness of the spectral colors contributes to confusion rather than to clarity.

Cartographers are not entirely to blame for their general conservatism and adherence to convention particularly with respect to lettering, color use, and structure. Private cartography, unlike some of the fields in the fine arts, has little popular support whereas commercial cartography dominates the broad market. In highly competitive fields, and in fields catering to the well informed, improvement functions as an asset. The average person who buys maps or causes them to be made, (school boards, teachers in various subjects, publishers and editors) are generally quite

17 Wright, Map Makers are Human, op. cit., p. 543.
uninformed about cartography and as a consequence buy what is already familiar. Since new plates, expert consultants, and new techniques are neither cheap nor guarantee income the commercial map producer is only too happy to peddle the older wares and reap an ever increasing rate of profit as long as possible.

Tradition and familiarity maintain a strong hold. On the other hand it is reasonable to expect that the developments in the science of vision and the spreading appreciation of the importance of design together with the marked increase of interest in cartography in recent years will tend to promote more critical examination of many of the long standing conventions.

The Evaluation of Cartographic Methodology

The confusion concerning the evaluation of methodology seems to arise, at least partially, from the failure to analyze the characteristics of perception applicable to the observance of a map. They are complex to be sure, but even if the present state of knowledge concerning them is relatively scanty, logic will illuminate some of the broader aspects. Experience and research in other fields of visual presentation may assist in the development of the logic applied to maps. Before an attempt is made to construct a basis for judgment it is necessary to admit that a map is a
functional object. That is to say, it must be granted that, for purposes of analysis, a map is constructed solely to accomplish an educational process. It is a technique, just as is scientific writing or the language of mathematics, whereby intellectual concepts are displayed for consumption. That from time to time a cartographer will include something for aesthetic purposes or will, by some technique or other, introduce a bit of levity on a map does not alter the basic premise. It is only necessary that when such is done, it be done consciously and with full realization of how such procedure will affect the resulting visual complex.

Cartography for educational purposes should be considered as no more or no less creative than writing. Physiographers have commonly employed diagrams and pseudomaps to clarify complex relationships such as are illustrated in figures nine and ten. This consideration of methodology as a procedural aspect of a creative undertaking is well recognized in writing. That master of functional writing, W. M. Davis, happily extended this thought to cartography when he wrote: "It is well known that there are many geographical matters which are better presented pictorially, cartographically, or diagrammatically than verbally. Hence it is just as important to study the proper and effective use of various forms of graphic presentation, as it is to study the values of different methods, treatments, grades,
Diagram to illustrate the development of block mountains

Diagram to illustrate wave action

Fig. 9. Diagrams to illustrate concepts and supplement written descriptions. (From William Morris Davis: Die Erklaerende Beschreibung der Landformen, Leipzig and Berlin, 1912, pp. 277, 472.)
Fig. 10. Illustrative diagram by A. K. Lobeck. (From A. K. Lobeck: Geomorphology, New York and London, 1939, p. 354).
and forms of verbal presentation". The ends desired thus dictate the means to be used to accomplish the purpose. The processes and functions which probably will occur between the eye and the mind of a reader must be predicted and analyzed if the methodology is to be properly evaluated. To do so is difficult to say the least. In the first place, there is not yet objective data upon which to base answers to many questions involving visual stimuli-mental response relationships. In addition cartographers and map-users have always been, and probably will continue to be slaves to convention, for as Miller points out, "Once a map convention has been established it is difficult not to feel prejudiced in its favor."

Part of a map is absorbed intellectually. That is to say, the visual shape and color of an object may be, through convention, completely or partially submerged in its intellectual connotation. Such, for example, are blue water, the dot-dash political boundary, and familiar lettering. The remaining components of a map enter the brain as visual stimuli without intellectual meaning except through prior


19 O. M. Miller: "An Experimental Air Navigation Map", Geog. Rev., Vol. 23, 1933, pp. 48-49. He cites the good examples of man-made conventions of southeast shadows in hill shading, and the convention of dark hills and light valleys when in reality they are (in the N. Hem. at least) just the opposite.
reference to a legend. Sometimes visual and intellectual qualities exist together in a single component. Often the differing components are side by side, and their very adjacency within the map frame causes each to modify the intrinsic visual qualities of the other.

These stimuli have only recently been appreciated as having an important bearing, other than aesthetic, in the consumption of a map. True, Eckert indicated some recognition of this nearly forty years ago when he noted that "... artistic appearance, particularly a pleasing colouring, can deceive in regard to the scientific accuracy of a map", but, except for color, it was not until the employment of maps as tools of propaganda that the importance of visual relationships was generally appreciated. Most of the writers on cartography have touched upon this subject, usually implicitly, rarely directly. Visual relationships are generally considered to be artistic or psychological components, that is to say, unfortunate elements of subjectivity which cannot be avoided, but which should be guarded against. There is, however, necessarily, a certain element of subjectivity in all small scale maps, if for no other reason than it is impossible to cram all mappable features on a

single map. Preuss points out that a scientific author usually presents the results of his selection and analysis, and asks "Should that not also apply to the map?" He comes to the conclusion that "scientific presentation must exaggerate the important and lay aside and repress the immaterial" and "... the lesson of practical, wise cartography is... to take into account the psychological element". Speier is aware that the visual elements can and do exert a significant effect on the consumption of maps, but it apparently escaped him that they could just as well be applied and utilized to further scientific ends. If they are to be utilized then it becomes necessary to recognize standards for their employment. The complete evaluation of cartographic methodology therefore requires that, ideally, the visual and intellectual properties of all map data, techniques, and media, be analyzed, as well as all the possible combinations of them.


22 Ibid., p. 70.

23 H. Speier: op. cit., p. 313. "The relationships of the different lines and areas we see, the shape of parts, the distribution of colors, symmetry or its absence — all these are extraneous to the scientific purpose of a map".
The Organization of Cartographic Methodology

The methodology of cartography may be defined as the science of the selection and use of cartographic procedures. The science, as previously pointed out, is in its infancy. There has not as yet been any systematic, logical organization of cartographic methodology. Very likely this is a result of the utter confusion existing in most of the literature in regard to content vs. technique. It is not difficult to see how this may come about particularly in a field which is so seemingly definite and precise by nature. To analyze cartographic methodology it is necessary to examine abstractly the makeup of a map in order to be able to classify the various phases of its methodology.

From the abstract point of view all the components of a map may be placed under two basic categories, (1) cartographic data, and (2) cartographic technique. As has been pointed out previously, it must be assumed that the selection of the data to be used on a map is primarily a function of the educational purpose to which the map is to be put and should, therefore, be determined without regard to cartographic methodology. This, of course can never be true in practice since the range of techniques with which to convey geographic information is not unlimited, yet for purposes of evaluation of technique, consideration of content, wherever possible, must be removed. Its presence cannot fail to
occasion responses which, consciously or unconsciously, will condition the evaluation of the technique. For this reason most preliminary advertising layouts are usually made up solely as organizations of value shapes. The removal of these intellectual factors for purposes of methodologic evaluation is by no means as simple in cartography as it may appear at first consideration. As was noted, it is impossible in practice to separate data from technique and since cartography is essentially a technique designed and existing for geographic data it may be expected that data will play a large role in its methodology.

Cartographic data may be either quantitative or qualitative. Quantitative data may be evaluated solely on bases of appropriateness as well as accuracy. The qualification of data involves problems such as the categorization and generalization of data, determination of ratios, and the choice of isograms and choroplethic limits. The qualification of data by such procedures must be included in a comprehensive classification of methodology, but it lies closer to the substantive aspects than it does to the presentation. On the other hand, certain components of qualitatively presented data such as comparative visibility

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24 The segregation of cartographic data into either quantitative or qualitative categories is generally recognized. For example see Alfred Hettner: "Die Eigenschaften und Methoden der Kartographischen Darstellung", Geographische Zeitschrift, Band 16, Heft 1/2, 1910, pp.
of shapes, color relationships, and a number of others involve problems of visual evaluation. When considered from this point of view these aspects must also be included in the evaluation of technique. Consequently, it would seem logical to separate cartographic methodology into two general categories, (1) substantive methodology, and (2) visual methodology. One must always admit, however, that there is no clear and precise distinction.

A map when analyzed solely as a visual thing is essentially a group of more or less related shapes of all sizes and values. The land-water relationship, the trim page, the map proper, the legend and title boxes, relative line width, the individual words, any massing of data, color, or value areas, etc.; all of these may (and should) be considered merely as shapes, varying in size, value, and color, and bearing a direct relationship to one another. In the broadest classification of map components, these all may be grouped under the term "design", and would so be considered if the map were being analyzed purely as a graphic layout problem. But a map is more than that. Each of these elements of "design" has intellectual limitations which cannot

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There is a third rubric in the complete classification of cartographic methodology, namely, map reproduction. It acts primarily as a limiting factor on the other categories.
be ignored; one is not able to organize the shapes freely; relative importance exists without regard to size and shape; and utility takes precedence over the aesthetic. A map cannot, therefore, be evaluated solely on the basis of pure design even though considerable insight into the problems of methodology can be gained by so evaluating it.

The lettering on a map is the first element requiring evaluation. Names and words are the shapes or symbols most submerged in their intellectual connotations, but they do have visual form, and as such are significant in the overall organization of the map. Their evaluation is based on two major aspects of their utility, the size and the design of the type face. In addition other important considerations in the methodology of map lettering include the appropriateness or suitability of the type face and the color of print and background and its effect on legibility.

The organization of the basic shapes within the map frame, that is to say its structure, have a significant bearing on the utility of the map. The controls which determine the possibilities of structural variation include elements of projection, balance, direction, and many others. The bases for evaluating these various factors are suggested through consideration of the visual stimuli produced by them as well as the intellectual responses.

The third element in the visual evaluation of a map is
color, used in the broad sense to include value and intensity as well as hue. It is perhaps the most difficult aspect of cartographic methodology since it is a significant element in both lettering and structure as well as in its restricted consideration. Its use with any other elements markedly affects their visual effectiveness. It has, however, one use more or less peculiar to it, the portrayal of categories of either related or unrelated data. Different hues, values, and intensities commonly appear in juxtaposition. It enters structural problems because its use changes the character of shapes. Thirdly, the color seems to produce significant emotional and intellectual responses.

These three visual components of cartographic methodology, lettering, structure, and color, encompass most of the aspects of a map capable of evaluation from the visual point of view. Bases for their evaluation in cartography will be suggested and investigated in the following chapters.
CHAPTER II

THE METHODOLOGY OF MAP LETTERING

Introduction

The lettering of maps is a complex and integral aspect of cartographic methodology. Although almost all maps contain some lettering there has been a tendency, growing in recent years, to consider lettering as extraneous to the map. A most extreme example of this attitude is presented by Raisz:

"The application of lettering is one of the most difficult problems of cartography. The essential of the problem derives from the fact that lettering is not a part of the map according to our definition, for it is not visible on a conventionalized picture of the Earth; but it is a necessary addition to identify features. The names by their bulk cover up many of the important elements of the real landscape and prevent the reader from seeing the map as a picture of the earth. On small-scale maps city names often cover hundreds of miles in length, even if printed in the smallest readable type, and their least disturbing placement is a trial to cartographers. The development of expressive cartography has been hindered more by lettering than by any other cause." 26

26 Raisz: op. cit., p. 156.
This attitude toward lettering undoubtedly extreme, is a reflection of the modern trend toward self expression. There would seem to be reasonably sound theoretical bases for this view with respect to topographic maps of very large scale, but even in such cases the gross assumption that all places and symbols can be made self explanatory or will be known to the reader is undoubtedly false. As has been pointed out earlier, small-scale cartography is a medium of presentation for spatial data and it follows that when such data need identification, then that identification becomes an integral part of the map. Its selection and its methodology should be covered by principles related to its purpose.

The identification of data and locations has always assumed an important place in cartographic methodology. For a great many maps, authorship and period may be determined merely by glancing at the lettering. Maps of the Royal Geographical Society (fig. 11), the National Geographic Society's maps (fig. 12), the wax engraved maps of the 19th and early 20th Centuries (fig. 13), and many others, are all clearly identified by their lettering which, in many cases, takes a prominent


28 Cf. Eckert's reaction to the Stumme map (Wissenschaft: op. cit., (Vol. I), p. 347), when he quotes from Peucker, "the lettering belongs to the map, as speech to men".
Fig. 11. A representative Royal Geographical Society Map. (From the *Geogr. Journ.*, Vol. 73, 1929, p. 306).
Fig. 12. Representative lettering on a map of the National Geographic Society. (From Wellman Chamberlin: The Round Earth on Flat Paper, Washington, 1947, p. 110.).
Fig. 13. Ugly type styles and over-lettering of the 19th Century. (Part of S. E. Morse: The Cerographic Atlas of the United States, New York, 1842, Map No. 32. Reproduced from Erwin Raisz: op. cit., p. 66.)
position with respect to the visual aspects. Although no
tests are known it is reasonable to expect, for most small-
scale maps, that the first reaction of the reader, conscious
or unconscious, is to the lettering, which in many cases is
necessary for the identification of the area. In the major-
ity of cases lettering with its background presents the
greatest value contrast on the map.

Although the sharp angles and complex curves of letter
forms make them one of the most complicated visual elements,
much of this complexity goes unnoticed since the shapes of
letters are well known to the reader. Even though familiar-
ity reduces the effect of visual complexity the inherent
shape differences between lettering and the other line work
on the average map causes the lettering to assume a rela-
tively important place in the visual scale. Only on a few
maps, such as physiographic or land-type diagrams or maps
of intricate coastal areas, does the other line work rival
the lettering in complexity. (Figs. 14, 15).

The evolution of lettering on maps is an interesting
study of the interaction of art, tradition, and convention.
For the last several centuries an additional influence has
been the method of reproduction. So long as copper engraving
was the principle process of reproduction there was no
problem in reproducing the finest hairlines and a progressive
degeneration of type styles took place on maps. For example
Fig. 14. Lettering on a terrain diagram.
Fig. 15. Lettering on land-type map.
(Drawn by E. Reisz from Preston E. James: Latin America, New York, 1942, p. 87.)
all semblance of proportion between the thin and thick strokes in Roman was lost. Type design improved rapidly after the general revolt against the mid-Victorian type styles, but cartographers were slow in taking back the initiative of styling the lettering for maps, being content to allow the engraver to determine the style. The practical problems of printing hairline work with the grained surface of zinc plates together with the preparation of copy for photography rather than engraving caused the general problem of map lettering to undergo review during the first half of the present century. Unfortunately there has been no extended research into the problem of styling lettering for maps and the present employment of faces shows neither consistency nor regard for some of the more important aspects of its methodology.

Like the other visual components of a map, the lettering should be evaluated in terms of its function. The function of lettering on small-scale maps differs from its purpose on large-scale and reference maps. In the latter kinds of maps the names are employed as a reference to be used when desired. A good reference map will obviously have a great many names and in general the criteria of selection and use of type will be modified by the desire to subdue them in order not to realize Raisz' fears that "their bulk will cover up many of the important elements". However, this
does not apply with respect to small-scale specialty maps wherein the entire map is prepared with a limited purpose in mind. Here the requirements must be based on the construction of a clear, homogeneous, and legible presentation of the data.

Withycombe in 1929 summed up the essentials in typography for maps as follows:

"The essentials to aim at are . . . .

1. **Legibility.** The letters not only must be legible when standing alone but also when superimposed in the detail of the map.

2. **Suitability for reproduction by the photographic process which is to be used.** . . . .

3. **Good style and intrinsic decorative qualities.**

   The style of the lettering on a map should be as good as that exhibited by the best fonts of type in use by book printers. As legibility is one of the characteristics of every really good alphabet, the first aim will be attained if really good style is achieved.

4. **Distinction and contrast.** Certain classes of names should be clearly distinguished and the different types of alphabets used and their gauge (point size) and spacing should achieve this.

5. **Harmony of effect.** The alphabets appearing on any one map should
The above analysis includes most of the factors to be considered in evaluating the lettering on maps and one which is no longer so important as it was when he was considering the problem. In the decade following the publication of Withycombe's paper many strides were made in reproduction techniques, and during World War II even more progress took place. A noted typographer and expert in the field of typography for lithography, M. T. Monsen, has stated categorically, "Any type face can be reproduced beautifully by photo lithography if the workmen . . . . know their trade and do the best they can". To be sure one cannot expect perfection in reproduction in all cases, but the evaluation of the lettering on the printed map in terms of the quality of reproduction is not a part of visual methodology. It is rather the evaluation of reproduction methodology.

Whereas Withycombe has combined many of the characteristics of map lettering into general functional categories for the particular purpose of analysing a specific series of type faces it would seem wise to investigate the problem in somewhat more detail. Probably the most fundamental and

frequent choice faced by the cartographer is that of size of lettering. Of only slightly less importance is the choice of a type face or lettering style based upon its characteristics of legibility, perceptibility, and fitness for the purpose. The orientation of lettering, the color of print, and the color of the printing surface are also important.

Before examining the bases for the evaluation of lettering methodology it would be well to point out that a great many maps, particularly specialty maps, during the early part of this century were hand lettered by the cartographers, draftsmen, and engravers. As few of these craftsmen can be termed experts in type design it is to be expected that a great many maps contain "type faces" which defy classification. The manual entitled "Topographic Instruction of the United States Geological Survey" in directing the style of engraving lettering specifies the faces only by such terms as "block", "stump", "roman", and "italic capitals". The Ordnance Survey of the United Kingdom uses similar language. Raisz employs such terms as "inclined gothic" and "italics". Only certain federal agencies, among them the Army Map Service, Bureau of Plant Industry, and the State


\[32\] Withycombe: op. cit.

\[33\] Raisz: Cartography, op. cit., pp. 156 ff.
Department have used commercial type faces for stickup. So far as is known only the National Geographic Society uses specially designed type faces.  

(Fig. 16) The reluctance of cartographers to use commercial type and the stickup process seems to be based primarily on the comparative newness of the technique. Prior to the last fifteen years the stickup process was laborious and the results not easily reproduced. Recently, however, many techniques for application have been developed and it is to be expected that in the future stickup will become the accepted process for lettering on most maps. The problem of selection of type faces will thereby be enormously increased because of the thousands of type faces from which to choose.

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34 The National Geographic Society has designed its own faces with reduction in mind. They have also invented (and patented) a photographic device which allows them to "compose" photographic negatives as type in a frame for exposure. The resulting positive is made adhesive and is used as stickup. The result gives the appearance of hand lettering with the precision of type. (See Wellman Chamberlin: "The Round Earth on Flat Paper", Washington, 1947).


36 It should be noted that type designed for book work is not entirely fitted for map use since the employment of type on maps is not always horizontal. Therefore, it may be expected that new faces will ultimately be designed specifically for map use. Such new faces, as well as any hand lettering, should, of course, follow the basic principles of type design, and would therefore conform to the general classification employed hereafter.
Fig. 16. Style sheet of the National Geographic Society.
The Form of the Type Face

The chief function of type is to be read, and legibility of type is a subject with many complexities of which the style of the type face seems to be a less important consideration than some others treated later. However, legibility does vary with type styles. A number of studies have been made on the subject of the legibility of various type faces. These may be divided in two categories, those concerning legibility, and those concerning perceptibility. Both show results of interest to the cartographer.

Comparative legibility of type faces is of importance in cartography in the selection of faces to be used in the following ways:

(a) Blocks of type such as legends and explanatory text.

(b) Place names and other material set closely as it would be in ordinary reading.

(c) Words, necessary on the map but subordinate to the main theme.

Comparative perceptibility is of importance in the selection of faces to be used in the following ways:

(a) Names widely spaced.

(b) Unfamiliar names.

(c) Names and words requiring different emphasis.

In tests conducted by Paterson and Tinker various type faces were employed in identical reading tests and the results
tabulated according to reading time. The faces selected are, by chance, fairly representative of some of the main groups of type (classified according to design) as recognized by Lopatecki. If the results are tabulated according to these groups of type, (Fig. 17) the Classic-Oldstyle leads, in legibility closely followed by the Modern and Sans Serif. The amount of difference among these groups is small enough to be immaterial. A Typewriter face shows a significant departure by being upwards of four per cent slower than Classic-Oldstyle, while the Text type retarded reading by over thirteen percent.

In a further test reader opinions were gathered and ranked concerning the legibility of the same type faces. As might have been expected there was little agreement between the two except that the Text type fell at the bottom of the list in each case. It is also interesting to note that the Sans Serif, although showing no marked effect on legibility, was considered to be distinctly less legible.

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37 Donald G. Paterson and Miles A. Tinker: How to Make Type Readable, New York, 1940, p. 16.

38 Eugene de Lopatecki: Advertising Layout and Typography, New York, 1935. Classification of type faces is not easy because of the subtlety of the differences in the gradation from one group to another. Generally speaking, writers on the subject have avoided classification based on visual characteristics alone and have grouped the faces variously on the basis of mechanical composition, designer, and period.

39 Paterson and Tinker: loc. cit.
This line is set in 14 point Cloister Old Style

This line is set in 14 point Bodoni

This line is set in 14 point Futura Medium.

This line is set in Trafton Script

This line is set in Stymie Bold

This line is set in Engravers' Old English

**Fig. 17.** Examples of classification of type styles according to Lopatecki. From top to bottom the groups, recognized by Lopatecki, are Classic-Oldstyle, Modern, San Serif, Script, Square Serif, and Text.
Generalizing from the above data, meagre though it is, it is possible to observe some significant results as applied to cartography. Perhaps most important is the result that apparently there is no marked difference between any of the standard types in the Classic-Oldstyle, Modern, or Sans Serif groups. It is safe to say that any type face in these groups which has stood the test of time will be equally legible for cartographic use. Choice of a face in the Sans Serif group should, however, be accompanied by a realization that reader opinion considers it less legible. It is doubtful if anyone would actually say "this type face is less readable", but the reason for the reader opinion as expressed in the test would be interesting. No explanation was offered by the testers. The Sans Serif group is a relatively modern type face. Its first representative, Futura, was introduced in this country within the present century and this face, together with the others in the group, show marked departures from the Classic and Modern group. Although somewhat related to a few of the Square Serif faces it appears quite different. Sans Serif is a radical departure from the commonly used faces and as such is bound to attract attention, a quality which may or may not be desirable in a particular cartographic composition.

In one of the first (and most complete) studies of perceptibility Roethlein showed that there are definite
differences among various styles of type faces, as well as among the various letters in each face. Of more significance was the conclusion that perceptibility depended, to a great extent, on the thickness of the line. It was found that perceptibility increases with increasing thickness of line until an optimal point is reached and then decreases. The studies were not extensive enough to reveal what the optimal is.

During the thirties Luckiesh and Moss developed a Visibility Meter and tested a number of type faces. From the visibility (perceptibility) ratings for each face they calculated the point size ratings for equal visibility. The table (Table 1) is of considerable interest since it seems to bear out Roethlein's contention that perceptibility is in large part dependent upon thickness of line. Bodoni Book was used as a standard, and an analysis of the table shows that all bold variations are (1) over 100 percent visibility and (2) an average of over eight percent more visible than the standard. It also shows that the most variation occurred in the Old Style and Modern faces and the least variation in the Sans Serif. Their calculations


<table>
<thead>
<tr>
<th>Type Face</th>
<th>Percent Visibility (Bodoni Book 100 percent)</th>
<th>Point Size for Equal Visibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 Point</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bodoni Book</td>
<td>100.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Bodoni Italic</td>
<td>96.0</td>
<td>8.3</td>
</tr>
<tr>
<td>Bodoni Bold</td>
<td>108.3</td>
<td>7.4</td>
</tr>
<tr>
<td>Caslon Light</td>
<td>96.2</td>
<td>8.3</td>
</tr>
<tr>
<td>Caslon Light Italic</td>
<td>81.1</td>
<td>9.4</td>
</tr>
<tr>
<td>Caslon Bold</td>
<td>106.5</td>
<td>7.5</td>
</tr>
<tr>
<td>Sans Serif Light</td>
<td>97.1</td>
<td>8.2</td>
</tr>
<tr>
<td>Sans Serif Medium</td>
<td>105.7</td>
<td>7.6</td>
</tr>
<tr>
<td>Sans Serif Bold</td>
<td>104.3</td>
<td>7.7</td>
</tr>
<tr>
<td>Cheltenham Wide</td>
<td>100.5</td>
<td>8.0</td>
</tr>
<tr>
<td>Cheltenham Bold</td>
<td>108.5</td>
<td>7.4</td>
</tr>
<tr>
<td>Cheltenham Bold Condensed</td>
<td>93.2</td>
<td>8.5</td>
</tr>
<tr>
<td>Light Copperplate Gothic</td>
<td>98.1</td>
<td>8.1</td>
</tr>
<tr>
<td>Heavy Copperplate Gothic</td>
<td>102.5</td>
<td>7.8</td>
</tr>
<tr>
<td>Goudy Light</td>
<td>94.0</td>
<td>8.4</td>
</tr>
<tr>
<td>Goudy Antique</td>
<td>106.2</td>
<td>7.5</td>
</tr>
<tr>
<td>Goudy Bold</td>
<td>104.8</td>
<td>7.7</td>
</tr>
<tr>
<td>Cochin Light</td>
<td>102.3</td>
<td>7.8</td>
</tr>
<tr>
<td>Cochin Bold</td>
<td>112.6</td>
<td>7.1</td>
</tr>
<tr>
<td>Garamond Bold</td>
<td>118.7</td>
<td>6.6</td>
</tr>
</tbody>
</table>

\(^{42}\) Luckiesh and Moss: *op. cit.*, p. 79.
show a variation in visibility between standard and bold faces of approximately 1 point size.

There seems to be ample evidence that type faces do vary in their effectiveness and that unless determinations of readability and perceptibility are considered in the selection of faces for maps, considerable variations in visual effectiveness may result.

Another common practice in cartography is the use of italic or slanting type. The choice between upright and italic for map use is usually based solely on the desire to distinguish categories of data by a change in type face. Although it is questionable whether this convention can be justified it is interesting to note that no work on cartography lists any objective basis for choice, while most works on advertising categorically state that italic type is more difficult to read. If the latter were the case then it would seem logical to abandon the convention, or at least to use this knowledge when employing italic.

Here again, as is the case with many cartographic techniques, no real study of the comparative legibility of italic versus upright type as used on maps has been made. A near approach is a study in legibility by Paterson and Tinker who determined the reading speed of several hundred persons with material set in upright and italic. The

\[43\] Paterson and Tinker: op. cit., pp. 20-22.
results are surprising since there was little difference in reading speed. However another test showed that reader opinion was definite that the italic was more difficult. Although reading speeds for the two styles were not far apart Paterson and Tinker also emphasize that there is a definite "possibility that italics may involve greater discomfort and greater expenditure of effort". Accordingly they make the following recommendation: "The use of italics should be restricted to those rare occasions when added emphasis is desired."

The study by Luckiesh and Moss, previously referred to, throws interesting light on the subject. Their study of visibility (perceptibility) as contrasted with legibility shows (Table I) that the italic faces consistently ranked less than 100 percent visibility. From an analysis of the table it may be seen that the only faces which ranked below 100 percent, in addition to the italics, were light faces. This leads one to believe that it may be the traditional lightness of face in italic that retards the visibility rather than the design. At any rate, this must remain conjecture since no comparable tests are known. Certainly, the conventional use of italic or slant letters for water features handicaps these features with respect to perceptibility.

44Luckiesh and Moss: op. cit.
Perhaps the question next most commonly faced in cartographic lettering, after the face has been chosen, is the decision of whether to use capitals or lower case for words. In general there are points of similarity in the conventions of cartography, with regard to this question, but no real standardization exists. Capitals are usually employed for the larger names, such as countries, oceans, and continents, and for such items of importance as principal towns, capitals of countries, and mountain ranges. Smaller towns and features of lesser magnitude commonly appear in lower case. This practice probably stems from the reasoning that capitals are more prominent, as well as from the unfamiliarity of seeing, in ordinary reading practice, large type set in lower case. Reasons for these conventions are not given in the literature and an analysis of letter forms makes it doubtful if the convention is well founded. Capital letters are less distinctive in shape than lower case. There are no ascenders or descenders in capitals, and the basic over all shape (including white space) of the letters is very similar. Capital letters take up more space than lower case and the number of reading fixations necessary is therefore greater. Most reading is done from lower case letters and it is therefore to be expected that lower case combinations would be easier to recognize.

Paterson and Tinker note that "The decreasing use of 'all capitals' in newspaper headlines and in advertising copy
suggests that printers and advertising experts are coming to believe that lower case text is more legible. Finding no satisfactory evidence upon which to base a determination of this question, they performed two tests on a total of over five hundred persons. The tests showed that lower case was read almost twelve percent faster than material set all in caps, and that reader opinion was nine to one in favor of lower case being more legible. In view of this evidence they recommend that "The headline writer and the advertising copy writer should henceforth abandon all capitals and should rely primarily on lower case." On the other hand, the difference in legibility may not be so great as to make it undesirable to use capitals for certain categories as, for example, different population categories or political divisions of differing magnitudes. It would seem that different combinations of point size, capitals, capitals and lower case, and capitals and small capitals would be preferable to a change in type style.

Although there is no question that words in lower case are more legible than all capitals it should be noted that much of the lettering in cartography is letter spaced to the extent that it is stretching a point to consider the arrange-

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45 Paterson and Tinker: op. cit., pp. 22-23.
46 Ibid., pp. 22-26.
ment a word. Actually, such letter spaced words consist, visually at least, of isolated letters. There is every likelihood that there is considerable difference between the perceptibility of isolated lower case and capital letters. However no known tests have been made. Roethlein’s tests are not applicable since size of the letters was not controlled so that they might be comparable.

In addition to the primary function of legibility, type on a map by its visual forms (and size) creates a number of impressions regarding texture, contrast, and mood. An examination of a large number of published maps ranging from soils maps to atlas maps shows the use of a maximum of twelve different type faces and a minimum of eight. It is believed that this is representative of most specialty maps. Obviously the choice of so many styles of type face from the thousands available should be based on objective principles rather than left to individual opinion and to tradition.

The use of type in cartography is similar to its use in advertising where the subject of type in display has received considerable attention. The purpose of type in advertising display is not exactly similar since considerable emphasis is placed on the aesthetic aspects of the various faces. It was pointed out earlier that the artistic should

\[47\] Roethlein: op. cit.
not enter into cartography to too great an extent since it was likely to attract attention for its own sake and thereby detract from the purpose of the map. In advertising this is desirable. In most cases, however, this caveat need be given little attention regarding type in cartography so long as the more standard faces are employed. Good type faces artistically speaking are usually good functionally. It does enter into the question of employment of the fancier faces. As Reeves so forcibly stated in the discussion following Withycombe's paper, "We do not want to attract attention to the names, but to the map features". 

One of the primary cartographic conventions is the practice of distinguishing the different features of a map with different styles of lettering. The epitome of this tradition seems to have been reached in the International Map, the style sheet of which shows at least twelve different faces of type. Hinks, in writing of this tendency, deplores the emphasis placed on variety by noting that, "A great part of this deliberate variety is superfluous, since there can rarely be any doubt about the character of the feature to which the name is attached, if the name is suitably placed".

Although he apparently was unaware of it, his opinion is concurred in by all writers on type display and typography.

\[48\] Withycombe: op. cit., p. 437.
Lopatecki categorically states "As a guiding principle, use only one kind of type with its variations...", and again, ". . . to attain typographic harmony . . . use only variations of one face. . . and . . . use as few of these, both in matter of weight and size, as possible". There seems thus to be a fundamental disagreement between the typographic experts and the conventional cartographer. While there appears to be no scientific basis for choosing between these two opposite views, one cannot help but favor the reactions of the typographic experts since they have had considerably more experience than cartographers in the field of type use and design. All designers, regardless of media, accept as one of the first principles of visual structure that all elements of a visual composition should be in harmony. This does not, by any means, obviate the use of contrast, but it does mean that contrast should be gained by variation of one or more of the elements of contrast without absolute opposition such as would obtain from using diametrically opposite type faces such as one face from the old style group with a member of the modern group. Justification is lacking for the convention of changing face for each feature or group of features on a map, but the assertion is common, and from a visual point of view it appears logical to follow the prin-

50 Lopatecki: op. cit., pp. 78-80.
51 Cf. ibid., p. 81.
ciples of typographic harmony until such time as justification for a departure from these principles is made.

The principles of typographic harmony are primarily based on the shape of the letters and have developed through years of use. They are stated only generally, probably because of the tremendous variety of type faces. The basic principle and the manner in which it is usually found is well illustrated by the following statement from Frazier: "Everything considered, the results which are the most satisfactory are usually found in the printing in which the question of the association of type faces does not enter, the printing in which but one series of type is used". Lopatecki lists a few possible combinations in addition to the general principles:

1) A strong geometric modern (Cf. Bodoni) with a sans serif.

2) Square serif with sans serif.

3) Sans serif with oldstyle.

One is forced to the conclusion that until much more objective studies of typographic harmony are made, the principles of the

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\[52\] J. L. Frazier: Modern Type Display, Chicago, 1920, p. 42. (This does not work much of a hardship since most common faces at least have six variants, such as light, standard, bold, extra-bold, italic, and bold italic.)

\[53\] Lopatecki: op. cit., p. 80.
typographic experts must be followed even if they are, un-
fortunately, primarily subjective. They have, however, stood
the test of time with frequent and wide usage. The latter
has not been the case in cartographic lettering.

Under the heading of "Harmony of Effect" Withycombe
states that the "alphabets appearing on any map should
harmonize... with the detail of the map..." 54 By this
he refers to two other aspects of the fitness of lettering,
texture, and mood, or appropriateness to the subject matter
and purpose of the map. Again, as in typographic harmony,
the bases for lettering methodology in these connections are
derived primarily from subjective experience.

This is not entirely the case, however, with regard to
texture. Different fonts have characteristic shape features
which may either harmonize well or contrast well with char-
acteristic shapes on a map. Contrast of shape is one of the
more important elements of visibility. If a map is con-
structed functionally the degree to which the lettering
should stand out or be subdued may be markedly affected by
choice of type face. A light face script type used on a

54Withycombe: op. cit., p. 422.

"In selecting a type to be used with line drawings it is
necessary to recognize some definite quality in the style
or execution of the drawing that may act as a guide in
selecting the appropriate design of type face."
line physiographic drawing will, because of the similarity of shapes, be "lost" in the lines on the map. This may or may not be desirable. A modern face, such as Bodoni, wherein the contrast between thick and thin strokes is great will appear "lost" on a map with a pattern of lines basically similar. (See Fig. 14) A map with a strong geometric quality would require a type face of rounded design such as Caslon or Goudy if the lettering were to stand out, or Sans Serif if it were to be subdued.

Of all the aspects of fitness of type on a map the methodology of mood is the most subjective. Yet, the existence of such an element in type faces cannot be doubted. Poffenberger and Franken made a series of tests involving the association of common objects and connotations in advertising with type faces and conclude that "the results of the experiment show quite conclusively that different type faces do vary in appropriateness." Lopotecki points out that ". . . type faces all have individual personalities. . ." and joins such adjectives as "austere", "elegant", "precise", "modern", and "dignified" to various type faces. Although the element of mood should unquestionably be included in


57 Lopotecki: op. cit., p. 83.
lettering methodology there is nothing in the literature to give guidance. In any case, as Poffenberger and Franken point out, the effects produced by type faces must be extremely mild. Further study is clearly required before definite principles can be evolved.

The Size of the Type Face

Perhaps the most common decision which must be made by the cartographer concerns the size of lettering to be used for the great variety of items which must be named on maps. Specifications for lettering are usually based on the size of the item or the space to be filled. It is also considered standard procedure to increase the size of the lettering according to the relative importance of places or things. Since a great many maps list a large number of names it may be expected that in general their size would be small. It is important, however, that the number of names be not so great that the smallness of type becomes unreadable. Like any material designed for visual consumption "Insofar as any data on a map cannot be grasped by the eye, and easily read, in just that measure is the map encumbered with useless material, and is a failure".

58 Poffenberger and Franken: loc. cit.

59 Cf. Raisz: General Cartography, op. cit., p. 161. "The size of the lettering should be in proportion to the size of the area."

In order to gain some idea of the standard practice in atlas production, twelve well known atlases were examined and the maximum and minimum lettering sizes estimated and tabulated in Table II. Most specialty maps conform to atlases in the size of their lettering although in general it may be noted that the smaller number of names on a specialty map makes it possible to raise the point size of the smaller names. It will be noted from the table that there is not much range and that the smaller sizes are small indeed.

Cartographers often speak of legibility in connection with lettering and complain about the smallness of lettering on maps, but so far as can be gathered no bases have been utilized in judging legibility other than personal opinion. Definite standards of legibility and perceptibility would be of considerable aid to a cartographer, for they would enable him to maintain full legibility throughout a map while grading the lettering according to the degree of visual importance assigned to any name or group of names. At present the reading glass is a necessity for those who frequently consult atlases.

As in other aspects of the methodology of lettering, type size varies both in legibility and perceptibility. The legibility of size of type is of importance insofar as blocks of explanatory lettering and the great mass of
<table>
<thead>
<tr>
<th>Atlas</th>
<th>Average size of smallest lettering in points</th>
<th>Average size of largest lettering in points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3 - 4</td>
<td>10 - 12</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>10 - 12</td>
</tr>
<tr>
<td>3</td>
<td>4 - 5</td>
<td>10 - 12</td>
</tr>
<tr>
<td>4</td>
<td>3 - 4</td>
<td>9 - 12</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>10 - 11</td>
</tr>
<tr>
<td>6</td>
<td>4 - 5</td>
<td>12 - 14</td>
</tr>
<tr>
<td>7</td>
<td>4 - 5</td>
<td>10 - 12</td>
</tr>
<tr>
<td>8</td>
<td>4 - 5</td>
<td>8 - 10</td>
</tr>
<tr>
<td>9</td>
<td>3 - 4</td>
<td>12 - 14</td>
</tr>
<tr>
<td>10</td>
<td>3 - 4</td>
<td>12 - 14</td>
</tr>
<tr>
<td>11</td>
<td>3 - 4</td>
<td>8 - 10</td>
</tr>
<tr>
<td>12</td>
<td>3 - 5</td>
<td>10 - 12</td>
</tr>
</tbody>
</table>

smaller names on a map are concerned. In a series of experiments on legibility Paterson and Tinker found speed of reading to be markedly affected by size of type. They point out that, for reading, "type sizes smaller than 8 pt. or larger than 12 pt. are quite unsatisfactory". Although the "reading" of a map and the reading of a printed page are two quite different operations, it may be expected that there is at least a degree of similarity between the two. If excessive fatigue results from reading type smaller than 3 pt. in a book it follows that similar fatigue will result when one attempts to find a particular name or set of names on an atlas page if the majority of the names are set in type smaller than 8 pt. The upper limit of legibility is of little concern since the large names on a map are not "read" as type in a book.

Of considerably more importance to cartographic methodology is the study made by Luckiesh and Moss on the quantitative relationship between visibility (perceptibility) and type size. In their experiments a kind of common denomina-


tor of perceptibility was established by reducing the amount of contrast between type and the background on which it was printed to a point at which the type was invisible, and then increasing the contrast until the type could be recognized. In general it may be considered as a score of relative visibility based on the angle subtended at the eye by objects, which is the basis for the normal testing of eyesight or, conversely, relative visibility. Using Bodoni Book type face the following scale of relative visibility was determined.

TABLE III

<table>
<thead>
<tr>
<th>Size in points</th>
<th>Relative visibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1.10</td>
</tr>
<tr>
<td>4</td>
<td>1.60</td>
</tr>
<tr>
<td>5</td>
<td>2.11</td>
</tr>
<tr>
<td>6</td>
<td>2.64</td>
</tr>
<tr>
<td>8</td>
<td>3.64</td>
</tr>
<tr>
<td>10</td>
<td>4.65</td>
</tr>
<tr>
<td>12</td>
<td>5.66</td>
</tr>
<tr>
<td>14</td>
<td>6.67</td>
</tr>
<tr>
<td>18</td>
<td>8.67</td>
</tr>
<tr>
<td>24</td>
<td>11.68</td>
</tr>
</tbody>
</table>

64 Luckiesh and Moss: op. cit., p. 89.
The authors also calculated the percentage of the maximum visibility for every two points of type and present the interesting curve shown as follows.

Fig. 18. Percentage maximum visibility according to point size.
(From Lukkiesh and Moss: op. cit., p. 94.)
Even a casual comparison of the figures presented in Tables I and II with those in Table III and Fig. 1 clearly indicates that cartographic methodology needs revision with regard to type size. Luckiesh and Moss, using accepted medical techniques, conclude that the threshold of normal vision is between four and five point type, yet standard cartographic procedure calls for a similar size for the majority of lettering on maps. Clearly the lettering sizes on maps have not been selected on the basis of readability. In addition to the problem of legibility the techniques have now been devised which give the cartographer an opportunity to select sizes of type in relation to the relative emphasis he desires to assign to names.

Luckiesh and Moss have in their two studies presented the foundation of lettering methodology for cartography. Their studies, of course, concern only one style of type. Similar curves should be worked out for all others likely to be used as well as tables of proportion one to the others. At any rate, bases for the functional use of type sizes have been established and only future research is necessary to provide the data for the effective evaluation of the methodology, with respect to type size.

65 On most maps the number of names increases, in general, with the decrease in point size.
Orientation of Lettering

The orientation of lettering on maps seems to be, in large part, based on the convention of placing north at the top of the page. Although there seems to be little basis for north orientation it is quite understandable why the corollary orientation of lettering should be considered desirable. If lettering were placed without reference to visible grid lines a confusing pattern would be set up between the regular grid and the irregular eye movements caused by reading the names at competing angles. With the exception of some survey and boundary lines the projection grid as shown on most maps is by far the most regular shape. It sets the pattern for the placing of all other moveable features including the lettering.

So long as the projection is one of the rectangular or conic variety it is simple to orient the lettering with the parallels if the map is designed with north at the top. If, however, the map is not laid out with north at the top the placing of the lettering with the parallels creates a most awkward visual organization and draws undue attention to the orientation of the map. Perhaps even more important is the consideration that most type was not designed to be read at an angle and it is likely that considerable eye fatigue would result.

The fact that most type has been designed to be used in horizontal form is probably the most important element of
choice in the orientation of lettering. Letter forms are very complicated visual forms and their designing is an exacting process. Each letter must fit forward and backward with each other letter both in capitals and in lower case. The shapes are adjusted many times before the letter is cut and it is therefore not surprising that when the letters are presented on a non-horizontal or curved base they attract attention by their unharmonious position and appearance. This is particularly noticeable along rivers where it is necessary for the lettering to follow the sinuosities of the stream in order that the eye movement be similar. Flat based lettering would be out of place. Very few letter forms have been designed especially for cartographic use and it is doubtful if those that have were devised with this problem in mind.

Many cases occur on maps when crowding requires that lettering be curved. It has been shown by Paterson and Tinker that the upper half of both capitals and lower case contains more clues to letter and word form than the lower half. It would seem logical that when curved lettering is necessary, separation of the lower portion of the word rather than the upper would aid in legibility.

The ideal criteria for the orientation of map lettering

are, like those for other components, based primarily on utility. This includes degree of emphasis desired and eye movement. Since most lettering is designed to be read horizontally it follows that anything not horizontal will attract attention by being somewhat confusing. This may be either positive or negative to the purpose of the map. If the orientation of the lettering is carefully standardized in a regular pattern the map appears stable and authoritative, regardless of its substantive quality. If the lettering is oriented variously the opposite effect is produced.

**Color of Print and Background**

One of the problems commonly faced by the cartographer is the choice of color of print and background. It is reasonable to expect that there would be differences in legibility and perceptibility as between various color combinations. The problem is not of minor nature since the use of color on a map almost automatically means there will be lettering thereon. Surprising as it may seem there is almost no mention in cartographic literature of this significant aspect of lettering methodology. With the increase in printing techniques and the associated construction

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techniques it is not difficult today to use colors on maps, and if the cartographer is interested in the visual effectiveness of his map, as he should be, color of print and background is at least as significant in cartography as it is in advertising. Since advertising is more commercial in nature, has attained importance more recently, and is less governed by convention, it is natural that the first experiments should have been reported in advertising texts. Since the beginning of the century a number of experiments have been conducted and published and the results clearly indicate that color of print and background is a subject of considerable importance to cartography.

The methodologic aspects are complicated. In addition to the variations of color of print and background, the possibilities of which are many indeed, other factors such as size of type, style of type face, and other points of emphasis influence the choice. Unfortunately the tests have which have been made are meager, although they show results of significance. They are not in all cases directly related to the problem of cartographic methodology since legibility and perceptibility of maps is not the same as in ordinary reading practice.

The development of the specialty map and mechanical screens during the last few decades and the employment of cartographic film rather than glass has resulted in the widespread use of white or open lettering on black, grey, and colored backgrounds. The use of this technique has been most common on the black and white map both because the majority of specialty maps are printed without color and because of the simpler reproduction techniques. What appears to be the first study of the perceptibility of black on white vs. white on black showed black on white to be more easily seen. Later studies and interpretation along the same lines, as cited and interpreted by Paterson and Tinker gave controversial results. In an attempt to arrive experimentally at an answer to this question Holmes and Taylor each conducted perceptibility tests. Holmes found that black on white could be seen at a distance almost 15 per cent farther than white on black. Taylor, employing


70W. D. Scott: op. cit., pp. 138-139.


a variety of tests, found that in every case black on white is more readily perceived than white on black. It is interesting to note that Taylor found Kabel Light in the larger sizes, a Sans Serif type face, to be perceived as readily in either fashion. Starch in a study of legibility found a 42 percent advantage in reading for black on white over white on dark grey. Paterson and Tinker measured the speed of reading with a larger number of persons. They report a 10.5 percent advantage for black on white. Reader opinion as reported by them was overwhelmingly in favor of black on white. (Fig. 19)

The above evidence indicates without serious question that black on white is more easily read and perceived than the converse. However, as applied to cartography, it indicates only that white lettering is less efficient than black lettering of the same size. If it is necessary or desirable on a map to use reverse or open lettering together with black lettering of the same size, the open should accordingly be utilized for data of secondary importance or some other adjustment made to equalize their effectiveness.

74Starch: loc. cit.
75Paterson and Tinker: op. cit., p. 113.
Fig. 19. Black print on white and white print on black. (The normal contrast in visibility is slightly enhanced in the illustration by the photographic process.)
A number of studies of legibility and perceptibility of black and colored print on colored backgrounds have been made. The investigations concerned with legibility variations are almost entirely in agreement. The broadest investigation (Tinker and Paterson) lists the following results from testing 850 subjects:

<table>
<thead>
<tr>
<th>Color Combination</th>
<th>Percent Slower Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black on White</td>
<td>0.0</td>
</tr>
<tr>
<td>Green on White</td>
<td>3.0</td>
</tr>
<tr>
<td>Blue on White</td>
<td>3.4</td>
</tr>
<tr>
<td>Black on Yellow</td>
<td>3.8</td>
</tr>
<tr>
<td>Red on Yellow</td>
<td>4.8</td>
</tr>
<tr>
<td>Red on White</td>
<td>8.9</td>
</tr>
<tr>
<td>(White on Black)</td>
<td>10.5</td>
</tr>
<tr>
<td>Green on Red</td>
<td>10.6</td>
</tr>
<tr>
<td>Orange on Black</td>
<td>13.5</td>
</tr>
<tr>
<td>Orange on White</td>
<td>20.9</td>
</tr>
<tr>
<td>Red on Green</td>
<td>39.5</td>
</tr>
<tr>
<td>Black on Purple</td>
<td>51.5</td>
</tr>
</tbody>
</table>

An interpretation of these and similar results of other tests is difficult because of the many variables over which no control was held or at least listed. Chief among these are chromatic aberration, the defining power of the various

77 Tinker and Paterson: *op. cit.*, p. 120.
78 Inserted from *ibid.*, p. 113. (Test covering 280 subjects.)
colors, their precise notation, and particularly their value differences. Paterson and Tinker recognize the importance of the last when they state "... legibility depends... on the brightness contrast between print and background" they even feel that they are justified in calling it "the law of brightness contrast". There is no question that value contrast (brightness) is significant but Paterson and Tinker seem to have overlooked the fact that in another of their tests, held with precisely the same controls, white on black is reported as 10.5 percent slower than black on white. Of course, the value contrasts are the same. Obviously, then, factors other than value contrast enter into the problem of legibility. There seems to be no doubt, however, that it is safe to make the generalization that dark print on a light background is more legible than the converse, and that as the value contrast decreases, so does the legibility.

Legibility, however, is only one of the aspects of lettering methodology and perhaps not the most important at that. Certainly in situations where attention value is desired, perceptibility is of equal, if not greater, importance. Again, it is to be expected that the general rule of value contrast will hold and the evidence supports

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Tinker and Paterson: op. cit., p. 121.
the contention. Summer found evidence, as might have been deduced, that colored lettering on a neutral or grey background was the most efficient. It is a well known phenomenon that neutrals (grey) in juxtaposition with colors enhance the intensity of the colors.

Conclusions

Lettering is an integral part of cartographic methodology rather than being extraneous to the fundamental purpose of the map. As the entire map is functional so should be the lettering. A logical examination of the problems of lettering methodology seems to provide the grounds for and, in some cases, evidence for the establishment of certain basic principles. These principles are of two types: (1) Those concerning the suitability of lettering for the intended purpose, and (2) those concerning the visual process of reading. That these cannot be separated is obvious. When lettering methodology is considered as being concerned with these basic essentials, it is apparent from the reasoning and from the evidence that the following con-


Conclusions have foundation:

1. The **Form** of the **Type Face**.
   a) Type faces vary in legibility and perceptibility with respect to differences in
      1) Design.
      2) Upright or italic.
      3) Capitals or lower case.

   b) Type faces vary in the degree of structural harmony with one another and with the detail of the map.

   c) Type faces vary in degree of appropriateness to subject matter.

2. The **Size** of the **Type Face**.
   a) Size of type has an important effect on the legibility and perceptibility of the lettering.

3. **Orientation of Lettering**.
   a) Orientation of lettering has an important effect on the structural harmony of the map.

   b) Orientation of lettering affects its legibility.

4. **Color of Print and Background**.
   a) Legibility and perceptibility vary significantly according to color of print and background.

Although the above enumerated general bases for the evaluation of lettering methodology are apparently sound the data necessary for detailed objective evaluation are meager. Further research is necessary, aimed at the special requirements of cartography. The designing of faces for cartographic use with particular reference to their reduction and orientation is perhaps most important.
Design as an Element of Cartographic Methodology

A map is a visual composition and its development like that of a written paper should be based on a reason-
ably complete outline of procedure. Like any written out-
line, the plan for a map includes the apportionment of
relative emphasis and the subordination of some of the
elements of subject matter. In the preparation of written
presentations the outline is concerned, in a sense, with
relative position and size in one dimension. That is to
say, the reader starts at the beginning and progresses in
one direction to the end. Emphasis is primarily dependent
upon arrangement, choice, and number of words. A visual
composition is considerably more complex. The possibilities
of arrangement are tremendously greater because their posi-
tioning is always in terms of two dimensions and in many
cases with at least an illusion or suggestion of a third.
The methodology of emphasis, clarity, and order of viewing
are made more complex, not only because of the two dimen-
sional presentation, but because the possibilities in terms
of technique combinations are almost unnumbered.
The construction of a functional cartographic presentation according to plan corresponds to the designing of any visual composition. Design in composition means order. Ross has summarized this accepted meaning of design as follows:

"What we aim at is... a form of expression which will be simple, clear, reasonable, and consistent as well as true. The attention must be directed to what is important, away from what is unimportant. Objects, people, and things represented must be brought out and emphasized or suppressed and subordinated, according to the idea or truth which the artist wishes to express. The irrelevant must be eliminated. The inconsistent and the incongruous must be avoided."

Such a procedure in visual composition is more exacting, and at the same time less exact than in written forms of presentation. In almost all small scale maps one of the basic portions of the outline, overall shape and position of land and water masses, is prescribed for the cartographer regardless of the specific function of the final presentation. For example few areas of the world present more difficult organizational problems than Japan. To utilize a rectangular shape means the waste of at least 50 per cent of the map area if Japan itself is the focus of interest. On the other hand the elements within the overall structure

are most numerous and are capable of almost infinite variety. Particularly is this the case with the so-called specialty map which is unencumbered by style sheets and standard specifications. Writing more than thirty years ago Hermann Wagner recognized the importance of design in the specialty map when he wrote:

"In order to draw such a map, the cartographer must himself be intimately acquainted with the authentic material on which it is based; he must use the most careful discrimination in selecting and arranging this material for the purpose of the map; he must insert every single feature, contours, name, figures, with the thought in his mind of their probable effect on the unfinished map; he must, in the actual process of drawing, give account to himself whether and why he ought to make a certain line lighter or heavier, a certain slope more or less steep, etc. He must, in one word, carry in his mind a perfect picture of that which he is to represent cartographically."

From Wagner’s characterization it is apparent that he felt that the specialty map depends to a large extent on the cartographer’s sense of design. Unfortunately nowhere in the literature of cartography is there any but passing treatment

of the principles of visual design, except perhaps in connection with color. That there are such principles of design applicable in cartographic methodology has been recognized in recent years but the recognition has not been accompanied by adequate review of the bases for its evaluation.

Fundamental to the consideration of design in cartographic methodology (small scale) are the problems and principles underlying the first step in any map making, that is to say, the visual bases for choice of map projections. This involves the recognition of distortion of shape and area from the visual point of view, rather than from the mathematical, and the techniques for evaluating such distortion. The conventional use of projections, the relation between their intellectual and visual function, and finally the question of orientation are all significant rubrics in the evaluation of map design.

No visual technique is more important in cartography than the principle of contrast. Although it is difficult to generalize concerning the relative importance of a part of an integrated whole, it is likely, all things considered, that contrasts of shape, size, and direction assume the dominant role in the majority of specialty maps. The principles governing the use of shapes, line widths, and the other elements of contrast have been carefully applied to the fields

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84 Committee on Cartography, A. S. P. G.: loc. cit.
of painting and advertising layout, but have had little recognition in cartography. Similarly the bases for evaluating the use of visual balance and proportion in cartography are poorly understood, if at all.

It is difficult indeed to separate the various aspects of design for application to cartography but it is necessary because of the straightforward intellectual function of cartography. One of the most important techniques affecting the design of a map is the use of color. The problem of color in cartography because of its intellectual relationship is better left for discussion by itself although it should be borne in mind that each of the principles of design included in the general headings of contrast and balance is markedly affected by the use of color.

Because the application of the qualities of hue, intensity, and value in color and black and white has been separated from the other design principles it would not be strictly accurate to refer to the following aspects of cartographic methodology as being "design". In place of this general term which encompasses the entire composition of a visual presentation (including lettering) the following may more properly be referred to as the structural elements of map design or simply as map structure, a term already in use in a more limited sense.
Projectional Elements of Structure

One of the many ways in which cartography differs from art is in the relative lack of flexibility in the modes of presentation on maps. This limiting factor in the visual design of a map makes itself felt in a number of ways, but none so fundamentally as in the matter of map projections. The projection constitutes a systematic reference frame and once chosen does not allow movement of the shapes defined thereon except through changes in orientation. The initial choice of a projection, however, is of considerable importance from the point of view of the visual structure of a map since the projection system to a considerable extent, especially on small scale maps, determines the basic arrangement of shapes. The possibilities of arrangement are greater than might be expected considering the precise nature of projections.

85 Cf. Marschner: op. cit., p. 41. "But the extent to which medium and small-scale maps retain the power of recording factual information in regard to distance, direction, and areal extent, is first of all dependent on the structural property of the framework on which the map is drawn. The map projection controls position and expanse in the feature expression of the map.

86 There is a general tendency in the literature concerning projections to complain, or at least imply complaint, because it is impossible to represent truthfully the spherical surface on a plane surface. From the point of view of visual structure, the "age-old problem of map-makers" might almost be considered a boon instead of an evil, since the opportunities for structural design would be greatly limited were the "perfect map" possible.
The methodology of projections for maps has many facets, a number of which are of primary importance to the intellectual aspects of maps, but which have little or no importance with regard to the visual. The very purpose of many large and some small-scale maps prescribes or greatly limits the choice of projection in such cases as orthomorphism for navigation, true azimuths from the center for radial plotting, minimum error and adjacent fit for sheet survey, stereographic for circles, and some others. For such maps intellectual function is almost the sole basis for choice. A second basis or group of bases for the choice of projection is required in those cases where intellectual function and visual structure together form the foundation for choice. For example, distribution maps require equivalence, for obvious visual reasons, which limits the choice to one group of projections, but structural considerations form the basis for selection therefrom. The combinations of intellectual function and visual structure which prescribe or greatly limit the choice of projection are many. Besides the basic requirement of equivalence for distribution maps many kinds of maps require specific combinations such as straight parallels and equivalence for presenting most climatic data, minimum error and conformality

for flight strip maps, and equivalence and minimum shape
distortion for atlas maps. In a great many cases, par-
ticularly with specialty maps wherein the primary function
is the presentation of a fact or a small group of relation-
ships, the visual structure alone assumes the significant
role and determines or should determine the choice.

The choice of a projection cannot be made, on the
other hand, wholly dependent upon visual considerations
except possibly in the field of cartographic illustration
when the illustrative function and the fixing of a general
visual impression is of fundamental importance. The popular
use of the oblique orthographic in recent years is a case in
point. There are, however, certain visual-intellectual
relationships inherent in the earth grid, in addition to
the well known properties of map projections, which play an
important part in the choice of a map projection for spe-
cialty maps. The simplest and yet the most fundamental of
these visual-intellectual relationships is the degree of
accordance between the arrangements of lines on the sphere
and on the projection. The several visual characteristics
of the earth grid are:

[Cf. the prefaces to Richard Edes Harrison: *Look at
the World*, *op. cit.*, and Erwin Raisz: *Atlas of Global
Geography*, *op. cit.* In connection with the use of the
orthographic each points out that basic visual impressions
of "global" spatial relations was considered the primary
function of the "global" maps rather than the data thereon.]
1. All meridians converge or diverge.

2. If the eye faces squarely a point on the globe, the meridian of that point appears on a straight line.

3. All meridians are great circles, the shortest distance between points. Hence, by visual implication, all meridians are straight lines.

4. All parallels are parallel.

5. All intersections of lines (except at the poles) are right angles.

6. All meridians are equally spaced along a parallel.

7. The distance between parallels is (at small scales) equal.

If we assume the map reader either consciously or unconsciously knows these fundamental facts then it is safe to say that he will unconsciously accept any projection on which they are or appear to be reasonably presented. Evidence that he will do so exists in the lack of criticism of most conic projections and particularly of the orthographic. (Fig. 20). The latter is especially interesting since its sole attribute of significance is its visual quality. Intellectually it would be difficult to find a more useless projection since scale, direction (except from the center of the hemisphere), distance, shape, and area all vary considerably. It should be pointed out, however, that beyond the bare essentials of the grid system visual comparisons from grid to grid are difficult because of the inherent
Fig. 20. The distortion of the orthographic projection. Note especially the areal distortion of the orthographic as compared with an equivalent projection. The linear distortion on the orthographic is well illustrated by the distances between the parallels — almost equi-distant on the earth. (From David Greenwood: Down to Earth, Mapping for Everybody, New York, 1944, p. 134, 137.)
complexity of the system. The eye is quick to notice departures from normal and when any of the above list of visual characteristics is defied in a map projection it is a source of irritation. This irritation is considerably lessened by familiarity with the problems of projection. Nevertheless, the cartographer should attempt to reduce such discrepancies to the absolute minimum, particularly since the projection itself is rarely the point of interest in a map.

The visual-intellectual relationship to function of map projections is a subject which has not received much emphasis in technical writing. Many are the examples of intellectual absurdity in regard to choice of projections when due regard has not been paid to the visual aspects. The prime and well-known example is the long argument concerning the desirability of equivalence as opposed to orthomorphism, and its reduction to absurdity in the case of the small scale Albers vs. the Lambert conic. The argument has real merit when large scale technical use is required, but Marschner summarizes the seemingly obvious

89Cf. S. (Reviewer): "The New Stieler Hand Atlas", Bull. of the Amer. Geogr. Soc., Vol. 36, 1904, p. 266. The reviewer writing of rectangular atlas maps cut from a large map and thereby capable of being joined, notes that "... moreover, it causes the central meridian to run obliquely across the sheet, to the perpetual irritation of cartographic nerves".

answer for small scale use when he points out, "When used for the same zone with the same standard parallels, the Lambert conformal and the Albers equal-area projections are so much alike in appearance that, from a visual inspection, they appear identical". An example of the degree with which the intellectual has sometimes been given precedence over the visual is the choice of the Minimum Error Rectified Conical Projection with two Standard Parallels for a map of the British Isles at a scale of 1:1,000,000 in place of the Albers equal area. The opposite, when the visual has been given entire precedence over the intellectual, is not uncommon in popular cartography. For example, many of the maps, even those of relatively large scale, in the Office of War Information Atlas, were thought to be made more visual by being constructed on the orthographic projection. Obviously, between these two extremes there is a meeting place in the methodology where the intellectual and visual aspects of projections can be brought to agreement. All that is required is an analysis of the functional requirements and a fitting of the visual properties. It is

91 Marschner, op. cit., p. 29.

92 C. F. Close: The Projection for the Map of the British Isles on a Scale of 1:1,000,000, H. M. Sta. Office, London, 1903. (Albers was discarded because the map was not to be used as a base map!)

93 Office of War Information: A War Atlas for America, New York, 1944.
doubtful if the search for the proper visual attributes necessary to satisfy any particular intellectual requirement needs be unfruitful, considering the hundreds of projectional possibilities. (Figs. 21, 22)

The literature on map projections understandably emphasizes the mathematical aspects and their visual attributes and shortcomings have received relatively little attention. A number of systems have been devised to present visually the characteristics of different parts of a projection and the difference in distortion between projections. Reeves, Jameson and Ormsby, Marschner, Fisher and Miller, and Chamberlin, among others, have plotted various figures ranging from a man's head to an equilateral triangle on different projections to serve as a visual means of comparison. The most systematic approach to analysis of deformation of shape and scale is, of course, the work of Tissot, who developed, in the latter part of the 19th

96 Marschner: op. cit.
97 Fisher and Miller: op. cit.
*Transverse Polyconic Projection. Axis and central meridian (165°) are true to scale and are great circles shown as straight lines.*

**Fig. 21.** The transverse polyconic projection. The adaptation of a projection to a specific purpose -- the great circle route as a straight line without the peripheral distortion which would be present in a gnomonic projection. (From David Greenhood: *Down to Earth*, New York, 1944, p. 127.)
Fig. 22. Visual use of the orthographic projection. Diagrammatic map by the author.
(From Vera Michele Dean: The United States and Russia, Cambridge, Mass., 1947, p. 41.)
century, his so-called indicatrix based on the earlier work of Germain. This technique (and the use of isomorphomorphic lines) has until recently received scant attention in the literature, considering the fact that it forms the base for numerical comparisons of the deformational magnitudes in projections. Marschner points out that such comparisons are possible only among elements of the same order, namely, linear error, angular deflection, and areal ratio. It should be possible, given such numerical data, to establish the beginnings of a scientific basis for choice which would be usable by the average cartographer as well as the mathematician.

The most fundamental visual problem, however, yet remains to be investigated. As Fisher and Miller point out, the restricted application of Tissot's analytical device "is of very little significance in considering the effect of distortion on the positional relationship between any two points at some distance from each other." The only non-graphical approach is Hink's statistical analysis

99 M. A. Tissot: Memoire sur le Representation des Surfaces et les Projection des Cartes Géographiques, Paris, 1881. (Reference from Marschner, op. cit., p. 5, who notes that the work was also published without tables, in Vols. 17, 18, 19, (1878, 1879, 1880) of the 2nd Series of the Nouvelles Annales de Mathematique.)

100 Marschner: op. cit., p. 9.

101 Fisher and Miller: op. cit.
showing error of distance and azimuth from the centers to the corners of some continental maps. There does not seem to have been any other attempt to compare the relative magnitudes of the deformations on the various projections. Until such a study is made, the comparison of projections with regard to the character of the "overall deformation" must remain on the less satisfactory base of visual judgment.

One of the strongest conventions in cartography is the orientation of maps with north at the top. It is difficult to understand how such a convention could have held power for so long. It is a universal tendency recognized in both the art of composition and in the use of maps that the top of a rectangle is "farther away in the direction a person is facing". Notwithstanding the fact that for many centuries it was standard practice to assign orientation on some logical basis, even if it were only religious or national interest, north orientation became fixed in cartographic methodology. It may well be that the convention had its origin in the visual qualities of the earth grid since orientation other than north would create an unsymmetrical grid. At any rate, the convention is so well established that when a map is not oriented "properly" it is considered

103 Raisz: General Cartography, op. cit., p. 80.
unorthodox.

From the point of view of education north orientation has little justification. Gulliver pleaded for it on the grounds that it was fundamental to the teaching of shapes and areas. Nothing could be more superficial since it is well recognized that shapes of objects are not actually learned when presented always in the same aspect. This is particularly true in regard to the locational relationships between shapes and areas. North orientation has even less justification in function since an experienced map user automatically turns the map so that "top" is in the direction he is facing.

It would seem logical that the orienting of a map should be based primarily on visual grounds which have their foundation in the intellectual function of the map. Thus the practice of route maps should be extended to all maps so that if there is a significant amount of "direction" in the function of a map (see Fig. 23) it should be so oriented. Other visual aspects will, of course, enter -- such as the incongruity of the placing of a large number of names at an angle to the grid, and the shape of the format. In general it is safe to say that many maps would benefit in terms of their inherent structural relationships if the convention

Fig. 23. Functional orientation. The map is intended to convey the impression of distance from London, not to London. (By the author, from Crane Brinton: The United States and Britain, Cambridge, Mass., 1947, p. 214.)
of north orientation had not become established.

Contrast as an Element of Visual Structure

As pointed out earlier the cartographer does not have the same freedom of choice as does the artist or advertising layout man, but nevertheless many opportunities are open in the adjustments of the elements of a map. One of the most fundamental of these opportunities lies in the visual structure of a map. In considering the methodology of map structure it is well to bear in mind that all the elements of structure, like all the components of a map, are interdependent. They can be separated only for examination of their methodologic bases. Of the elements of structure probably the one with the most widespread application is the principle of contrast. The components of a map which are capable of being varied according to principles of contrast are (besides the lettering) the legend boxes, the title area, the graphic scale, the symbols used, and especially significant in specialty maps, the various lines employed throughout the map.

In cartographic methodology the problem continuously facing the cartographer is to assign visual importance and

North orientation will continue to be common since in many cases the visual values of other orientation will be overbalanced by the resistance of the clientele to ignoring conventions.
distinction commensurate with the values of the intellectual concepts being presented. Such components as the legend box, title, and graphic scale, are not always of equal importance to the particular map or among similar types of maps. For example, the title of a map of North Africa may ordinarily be considered as relatively unimportant since the area so shown tells by its shape the coverage involved. On the other hand the title on a map of a section of the continent or of an unfamiliar area such as a minor island is of considerably more significance. The legend box of many maps is of passing importance particularly when the symbols used are entirely conventional and well-known. In other cases the legend box may hold the key which makes the map intelligible. In some maps scale relationships are fundamental whereas in others the scale is incidental. Some items symbolized are more significant than others. Similarly the various lines on a map vary in importance.

The principle of contrast includes several applications of which contrast of size is of fundamental significance. Contrast of size has two applications, all other aspects being equal:

106 Cf. The formula developed by Fretwurst (Eckert: Kartenwissenschaft, (I), op. cit., p. 343) for title lettering! The formula reads, \[ h = \frac{2.I}{\sqrt{I}} \] where \( h \) equals the height of the lettering in \( \text{mm.} \), and \( I \) equals the area of the map within the neat lines.

1. The larger an item is the more important it appears.

2. Equal size divides interest equally and produces confusion and monotony.

The methodology of size contrast cannot be evaluated in the simple direct way it can when the designer has complete control over the shapes which enter into his composition. For example, no matter how significant the title of a map may be it is doubtful, or at least very unlikely, that it can be made the largest item in the map structure. Similarly, the legend box and the graphic scale, although capable of variation cannot, in the majority of cases, be made to overshadow the map itself. It is perhaps better to approach the problem through the media of convention and tradition which, although relatively subjective, can suggest a base from which to depart. A map, like an advertisement, should not (except possibly in the case of standard reference maps of well known areas) be a barren aggregation of shapes but should, like an advertisement, tell its story through the use of design principles. After the appropriate degree of intellectual emphasis has been assigned to each of the components the principle of contrast of size may be applied by varying the sizes from what would result if all components were equal in importance.

The second application of the principle of size contrast is particularly important with respect to the lines appearing on a map. Lines on the earth are generally pre-
determined in length, complexity, and overall shape by the existence of the phenomenon to be portrayed. The only opportunity the cartographer has to vary the lines is in size and in character. A great many maps are apparently made on the assumption that the latter is of more significance in creating contrast. (Fig. 24) Although no tests of relative visibility or degree of visual distinction between line weights and character are known it would seem logical that character of line is not as great a factor in determining relative visibility as is size. All other things being equal the angle subtended at the eye by the object is the determining factor in visibility. Whether a line is made up of dots and dashes, or any other combination, it is still a line which varies in thickness.

Another application of the principle of contrast of importance in cartographic methodology is the principle of shape contrast. Although the basic shape with which the cartographer must deal is predetermined by the area, he is, within limits, able to vary the character of the shape of such components as the legend box, blocks of lettering, logos, and titles.

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108 eg. Rows of dots, dashes, etc.

109 Cf. Luckiesh and Moss: "The Quantitative Relationship Between Visibility and Type Size", op. cit.

110 It is reasonable to suppose that if the separate symbols, such as dots, used to simulate a line are much farther apart than their width that the eye will fix upon the individual pieces, so to speak, and the resulting visual impression will, fundamentally, be one of a series of jumps even though eye movement is induced by their arrangement.
Fig. 24. Use of lines varying only in character. Entitled "Centers and Routes of Wheat Movement in the United States and Canada" this map uses six kinds of lines which are differentiated primarily by character. The straight solid lines (showing wheat movement all the year) are particularly confusing where the state boundaries are also straight. (From Clarence Fielden Jones and Gordon Gerald Darkenwald: Economic Geography, New York, 1941, p. 289.)
symbols and lines, either in the legend or elsewhere on the map. The principles of shape contrast which apply to these components of a map is similar to the application of the principles of contrast in size, namely, monotony or extreme complexity of shape retard visibility while simple differences in shape promote interest and enhance visibility. (See Figs. 25, 26, 27).

So far as is known no tests have been made to determine the quantitative visibility characteristics of the basic shapes. Undoubtedly there are varying magnitudes of dissimilarity of shape which increase visibility. Conversely there are undoubtedly values of equality of size, given different shapes, which are of significance when the cartographer wishes to distinguish between two or more components, but must assign equal visual values to each. It is common knowledge, for example, that a round shape seems larger than a square shape with the same area. Exact values are needed.

Another principle of shape contrast of considerable significance to the cartographer is that, other things being equal, the more complex a shape is the greater interest it seems to have for the eye. The operation of this principle is particularly noticeable in the relation—


Ibid., p. 30.
Fig. 25. Monotony of shape. Note the difficulty of distinguishing the various naval bases, all being the same shape and character. (From Emil Berlin and Varian Fry: War Atlas, New York, 1940, p. 69.)
Fig. 26. Extreme complexity of shape. Letters make poor symbol forms for a variety of reasons one of the more important being their complex visual form. (From Lester E. Klimm, Otis P. Starkey, and Norman F. Hall: Introductory Economic Geography, (2d Ed.), New York, 1940, p. 243.)
Fig. 27. Good shape contrast. The simple shape contrasts enhance visibility and recognition. (From Rudolf zu der Luth: op. cit., p. 8.)
ship on many maps between the coastline and the linear data thereon. As Ridgway has pointed out, accurate intellectual generalization "should mean the same degree of omission of detail for each kind of feature". Such generalization often results in natural features being remarkably complex visual shapes and thereby attracting the eye away from the more important presentation. Raisz has noted there is often "a discrepancy between the details of the shoreline and the broad generalized belts placed upon them" and recognizes the advantages of visual simplification.

Although intellectual simplification or generalization is of fundamental importance in map making as Wright has clearly shown, the problem of visual generalization, in relation to map structure, although not so well understood is of equal importance in the clear presentation of scientific data.

The third application of the principles of contrast


114 A particularly good example are the two maps in Fig. 151 of Southern S. America in Clarence F. Jones: South America, New York, 1930, p. 345. Although side by side, and intended to show historical sequence (sugar, and vineyards in Argentina and Chile) one has a much more complex coast of Chile than the other.


116 John K. Wright: "Map Makers are Human", op. cit.
in visual structure deals with the phenomenon of eye movement through the manipulation of shapes, values, and lines. Like all elements of visual structure it is difficult to separate this aspect from the other elements. Also some of the important elements causing eye movement are better left for review in the chapter on color.

Ross, in his detailed analysis of the principles of design, shows many ways in which the eye can be induced to move (called direction by the artist) through the manipulation of positions, lines, outlines and tones. These techniques are of importance in the methodology of a map since, like any visual composition, the data of a map cannot be grasped in one glance or by concentrating on only one point. The eye, in order to encompass the entire presentation, must move from place to place. Since the components of the map are obviously, in all cases, of differing importance it would be desirable to lead the eye in the direction and sequence necessary for the proper grasp of the complicated material. In other words, the principles of movement would enable the cartographer to construct the presentation in visual accordance with the intellectual aims.

The first principle of movement in visual structure is that "every unit in the design of a layout, unless it is of the same width as height, points in the direction of its longest dimension." This principle, of considerable importance in advertising, has less application in cartography since the fundamental shape, the area mapped, is already determined; whereas in advertising there is danger of the reader being led off the layout to an adjacent one. Since we can assume the map reader wants to look at the map the above principle is important in directing his eye toward the significant features thereof, which may be the legend, scale, title, particular area or relationship, or marginal information. Lopatecki also suggests that "any unit that has a definite pointed shape will point", and suggests that the general rule for stopping eye movement is to arrange another unit at right angles to the first. (Fig.28) Although no tests or experiments are known to exist concerning the application of these principles it is likely that they are of considerable significance, not only in the arrangement of map components, but in the overall map shape as well. It would be instructive to have the results of

118 Lopatecki: *op. cit.*, p. 22.
Fig. 28. Confusion resulting from eye movement. The boundaries of the rainfall areas are difficult to follow because of the many directional changes caused by the patterns and isohyetal boundaries. (From George B. Cressey: Asia's Lands and Peoples, New York and London, 1944, p. 21.)
visual tests conducted on the relative efficiency for inducing concentration of the oval world projections, such as Mollweide and Aitoff, compared to the interrupted pointed projections such as the Sinusoidal and Parabolic. (Fig. 30).

The various factors of contrast often are found occurring together especially in what is sometimes called the figure-ground relationship. This aspect of design refers to the visual relation of one or more components to the background on which they are seen. Although it becomes most apparent in symbol shapes and in maps suggesting pictorially the third dimension it is also of considerable importance in helping to define the area of interest in a map. (Fig. 29) For example, the use of water lining, shading stipple, or perspective raising of coastlines are devices which make clear the land-water relationships.

One of its most obvious manifestations is in the use of spherical or cubical (block pile) symbols, the shape of which is intended to raise them above the general map "level." (Fig. 29) There is, however, danger in using such symbol forms in that the technique tends to enhance the visual value of the lower categories or, vice versa, lower the value of

Fig. 29. (Next page) Figure-ground relationship. An example of two aspects of figure-ground relationship. The value supplied by the dots for rural population clearly sets Ohio apart from the "ground" area surrounding it. The apparent spherical shape of the urban population symbol "raises" it above the Ohio "level".
(From Guy-Harold Smith: op. cit.)
the higher since the actual amount of area covered by the symbols varies according to cube roots.

Balance and Proportion

One of the essentials of writing deals with the maintenance of a proper relationship among the features being presented. The appropriate amount of detail and emphasis should be applied to each element. A visual composition should be so devised and arranged, insofar as possible, that each component appears logical both as to position and degree of emphasis. There is little basic difference between the construction of a written outline and a visual outline. The techniques are different, but the functional bases are the same.

In cartographic methodology the visual "outline" is a complicated combination of the application of the principles of overall shape, balance, proportion, and unity. These general principles, difficult to define and poorly understood scientifically, enter into every visual composition. More so than in the techniques of writing, each modifies the other and an almost infinite variety of arrangements are possible. Many of the principles have been derived by trial and error method through many centuries of work by artists and designers. So far as is known they have not been tested in specific application except insofar as their persistence
against competition may be considered testing. Until such time as logic and objective research concerning the relative efficiency of the various possibilities is undertaken, the cartographer can but rely on the experience and direction of the artist.

Cartographic methodology as concerned with map structure includes the problem of format or overall silhouette, as distinguished from the shapes entering into structural relationship within the map. Ordinarily the cartographer, like the advertising layout man, must work with a prescribed format but within that shape he is usually able to exercise some freedom. Although the literature is singularly bare of references to this problem in methodology the numerous possible approaches indicate that some basis for judgment would be desirable. Eckert attempts to generalize on a visual-intellectual basis by suggesting that the format should be rectangular and only circular or oval when it concerns the whole earth. There has recently been a tendency to return to the circular shape in the "air age maps" presumably to emphasize the sphericity of the earth.

122 Except in the case of "bleeds" when the problem becomes primarily one of internal proportion, the format being prescribed by the trim lines.


A number of world maps are "interrupted" such as the Homolosine and show quite unique and irregular outlines. The problems and cartographical results of fitting desired scale, area shape, and prescribed format are legion.

Fundamental to the methodology of format is the principle of unity. Lopatecki summarizes the principles of unity by pointing out that "... all the units which go to make up a layout must be organized into a single whole", although he was not considering a format as being involved since there is a strong tradition in advertising layout concerning format. Keeping in mind the principle of unity it may be seen that the principles of structure outlined under contrast, particularly concerning directional components, are of considerable importance. For example, the pointed shapes of the interrupted sinusoidal tend to direct the eye away from the map, and do not in any way help to suggest the desirable unity. On the other hand if the same or a similar projection is used with a border or with strong color contrast as to center the attention the principle of unity is not seriously violated. (See Fig. 30)

125 Lopatecki: op. cit., p. 49.
127 Cf. ibid.: Landforms, p. 2.
Fig. 30. The interrupted sinusoidal projection. The convergence of the meridians toward the poles tends to lead the eye toward the points. The "one world" concept is difficult to maintain. (From Army Service Forces: Atlas of World Maps, M-101, Washington, 1943, p. 28. Half reduction from a color original.)
There are a few visual procedures which aid the cartographer in working out format problems. The layout man usually works from a format to his composition while the cartographer, because of the prescribed shapes, must start with some of the more important shape elements already determined and in many cases their basic organization prescribed. The drawing of a frame or the decision as to scope can be greatly facilitated by bearing in mind the principles of balance and proportion.

The principle of balance is well stated by Lopatecki:

"Every layout requires stable equilibrium or balance. The masses must be so weighed against one another that they appear to have settled in the positions they occupy -- to belong there in other words. No unit of design should convey to the eye of the reader the idea that it is struggling to go somewhere else in the layout, nor should the layout look as if it were tipping over."

Visual balance begins with the focal center which lies on the vertical center line approximately five percent above the mathematical center. Around this optical center the units of a composition should be balanced visually. The factors affecting the visual balance of a composition are the distance from the center of the components, their weight (value), their size, and their shape. In cartography, as


131Lopatecki: op. cit., p. 27. Because so much of the
previously pointed out, basic shapes and the intellectual importance of the components are usually predetermined and the cartographer must therefore analyze his subject matter, decide where he wants his optical center to be, and then construct his frame.

The principles of visual proportion as related to cartographic methodology may be summarized as being the relation which the size of one part bears to the whole and to the other parts. In design the subject is of great importance and a large literature has been developed on the theories and history of proportion. Much of it is very technical being based on mathematical and geometrical principles but little is applicable in cartography since the cartographer does not have the necessary freedom to vary his shapes and sizes. It does have application in the determination of the map frame and in the shapes and positioning of the non-map components such as legend-boxes, blocks of explanatory text and other shapes with which the cartographer is relatively free to work.

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132 Lopatecki: op. cit., p. 33.
133 A brief summary is given in Lopatecki: ibid., p. 33-44. The theories of proportion and symmetry are of interest to the cartographer since it aids him in the appreciation and analysis of associated visual design.
One of the fundamental principles of proportion seems to be that the rectangle is the most pleasing shape, although the circle has been described as the "most harmonious of all outlines". The rectangle is the more common and because of its acceptance by designers and its conventional employment it may be considered desirable except when some other shape is clearly indicated. In layout and design considerable attention is paid to the actual dimensions of the rectangle and elaborate schemes involving diagonals and reciprocals are employed in working out the internal structure. In cartography the area and scale usually dictate to a considerable degree the proportions possible, but one of the negative applications of the principles of proportion should be employed in the choice of a rectangle. The square and the rectangle with obvious mathematical relationships between the sides is not considered as pleasing a figure as one wherein such relationships are not apparent to the eye.

Conclusions

It is undoubtedly apparent from the foregoing that structural elements in cartographic methodology are not only extremely complex, but poorly understood as well. The reason

134 Rowse and Fish: op. cit., p. 170.
135 Ross: op. cit., p. 98.
why visual composition is so subjective and devoid of objective testing is probably, or at least partially, due to the assumption that, because of the infinite number of possibilities, any testing of isolated components would be of little actual worth. It seems likely, however, that a number of cartographic procedures could be evaluated by testing. For example, there is undoubtedly a minimum width difference, and angular difference easily apparent to the eye. It should be possible by testing to arrive at a reasonably accurate area departure factor which when applied to different shapes would bring them to comparable visual size. On the other hand, many of the aspects of harmony, movement, balance, and proportion, seem likely forever to remain essentially subjective insofar as their evaluation is concerned. This does not mean to imply that the principles governing their use are purely a matter of individual caprice; it does mean that exact standards probably cannot be devised.

The one aspect of map structure which seems to have definite possibilities for objective visual evaluation is the projectional. Heretofore, almost the entire literature on projections has been concerned with the mathematical phases. Only recently has the visual problem become significant in the selection of projections, but so far little has appeared in the way of logical argument beyond the self-
evident assertions that a circle represents the hemisphere and that a perspective drawing of the surface a globe looks like the surface of a globe. It is in the field of visual evaluation of projections having significant properties for small scale cartography that investigation is required. Visual illustration of distortion has been presented in numerous cases but objective analysis is lacking. Tissot's investigation seems to provide the basis for such analysis. Considering the present state of cartography in regard to structure, it seems wise to suggest that design has a negative side as well as a positive. Excessive repetition, ignorance of figure-ground relationship, the use of uninteresting shapes, the lack of focus or contrast may well detract from the effectiveness of a map just as much as their opposites would add to its effectiveness. (Fig. 31)
Fig. 31. Negative design. Poor contrast makes the water-land relationship practically invisible and suggests a population density on the water. The excessive use of parallel lines causes eye fatigue. (From Edgar Ansell Mowrer and Marthe Rajchman: Global War, An Atlas of World Strategy, New York, 1942, p. 79. Slight reduction.)
CHAPTER IV

THE EVALUATION OF COLOR METHODOLOGY

Introduction

Of all the subjects of cartographic methodology, color is probably the most complicated and the least understood. Notwithstanding, it is a subject on which most cartographers and writers do not hesitate to discourse. Color is widely used in cartography and it is likely that its use has been more influential than any other technique in the creation of the conception of cartography as a branch of subjective art. This is not surprising for color has been the main media of art throughout recorded history. Color has always stood a little apart from other representation techniques because of its closer alliance with things aesthetic. Although color has always been considered important in cartography it did not attain widespread use until chromo-lithography was developed during the first part of the 19th century.

137 It is interesting to note that in the time of J. Perthes (c. 1800) the illumination of political boundaries and coastlines was done by the society ladies of Gotha strictly for enjoyment. (Eckert: Kartenwissenschaft, (II), op. cit., p. 688.)
Since that time color has come to be indispensable in important cartography. It is considered so important that the making of a map without color is now a kind of negative undertaking, that is to say, a black and white map is usually constructed because color could not be used. Eckert asserts that "For many of our modern maps, particularly the special purpose maps, colors are indispensable" and "Black and white maps grow monotonous". Those words were written before the developments which make possible the tremendous variety of techniques for black and white presentation. The technical procedures for variations of black and white work are not well known or widely used in cartography, and even if they were it is doubtful whether the general attitude toward the importance of color would be markedly affected.

In cartographic methodology the use of even one color in addition to black seems enormously to increase the clarity and the ease with which an item or group of data can be emphasized. This is frequently caused by the phenomenon noted earlier, namely, that the visibility of base data (lettering, grid, hydrography, etc.) is lowered by its colored background. Much of the enhancing of visibility by

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138 Eckert: Kartenwissenschaft (II), op. cit., p. 689.
139 Cf. Clarence P. Hornung: "Art Techniques and Treatments," Seventh Annual Advertising and Publishing Production Yearbook, New York, 1941, pp. 18-33. Over 100 possibilities are shown out of the "limitless number of variations possible."
the use of color is likely to be due in large part to the
general ignorance of design principles in cartography, but
even if the potentialities of design were widely employed,
color would still assume a most significant place in carto-
graphic methodology. Color seems to produce effects
beyond legibility, in the aesthetic sense as well as the
non-artistic subjective. For some reason, as soon as color
is applied to a map the color becomes a focus of criticism.
Everyone, regardless of his familiarity with the principles
of color use seems to feel he is entitled to discourse upon
color on the basis of his own likes and dislikes. It is
noteworthy that, although structural design principles and
effects as well as typography are frequently slighted in
reviews, the use of color commonly occasions comment. The
increased color reproduction facilities as well as the
growth of propaganda maps during the last decade or so, has
brought a realization of the danger of using color hap-
hazardly. Nearly forty years ago Eckert pointed out that
"... artistic appearance, particularly a pleasing colour-
ing, can deceive in regard to the scientific accuracy of a
map." During the recent war the propaganda uses of
color were commented upon, and although the dangers were

fully realized and presented, little seems to have been suggested to raise the standards. It is surprising that this subject, acknowledged by most writers to be of extreme importance in cartography, has not been investigated to the fullest extent by cartographers. As a matter of fact the use of color in cartography received more study during the last half of the 19th Century (beginning in 1850 when facilities for its use began to become available) than it has during the first half of the 20th Century.

Prior to and even during the first half of the 19th Century the color which appeared on maps was applied either by engraving, (wood or copper), or by hand illumination. Even after the development of lithography, copper engraving, although more expensive, was still used for the more precise and valuable maps. It was not until the development of the various combinations of photography, gravure, and metals with lithography, toward the end of the 19th Century, that color became relatively common in cartography. By that time considerable investigation in the principles and characteristics of color vision had been made, and Peucker utilized

142 Cf. Speier: op. cit., and Wright: "Map Makers are Human", op. cit., p. 347.

143 The classic work on color contrast and harmony (M. E. Chevreul: The Laws of Contrast of Colour, and their Application to the Arts -- translated by John Spemton, London --) had "Map Coloring" as part of its subtitle in the original edition published in 1835. Chevreul's work has been ignored in cartographic literature.
these developments in his study of shadow plastic and color plastic in relief representation. Following the early investigations of Peucker many others carried further the research into the employment of colors on maps, particularly in the field of land form representation. Considerable progress was made and the concepts of warm and cold colors, stereoscopic effects of colors, hue, value and intensity differences were apparently fairly well known among the European cartographers. This period, prior to the first World War, may be characterized as the most productive in terms of the application of color science to cartography.

The progress in reproduction techniques after the first World War was rapid and although great strides were made in the technical procedures little or nothing was done to carry forward the research which started with Peucker's efforts. As a matter of fact the period was in a sense negative rather than positive. While little if anything was done to further this line of research, a great deal that had been accomplished was forgotten, at least in American cartography. This is understandable, even if unfortunate. As the techniques of reproduction have grown more numerous and complicated the familiarity of the cartographer with such processes as deep etch, gravure, process color, wash, and the various

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144 A good summary of this work and its effects is contained in Eckert: Kartenkissenschaft, (1): op. cit., p. 625 ff.
screening techniques grew relatively less. As a result the cartographer, usually not being competent to direct, left considerable of the color production responsibility to the lithographer and engraver. Consequently, the application of color to many maps was under the direction of those who were not only unfamiliar with cartography but were even less familiar with the presented data. It is not surprising that cartographic quality declined.

That the pendulum has begun to swing in the other direction, however slightly, is evident from a number of publications: The 32nd Yearbook of the National Society for the Study of Education asked for more research in the legibility and psychological effect on maps of colors. The Encyclopedia Britannica employed a color artist for a series of world maps in their Atlas. The experience of cartographers during the recent war resulted in a plea for more care in the selection of colors. Unfortunately, this evidence is meagre and, although it indicates a move in the right direction, does not promise much. No modern studies comparable to those of Peucker or his followers have been undertaken and even the current critiques of maps show little familiarity with color science. Color work is described as "pleasing", "of good quality", or "mediocre",

145 Eldredge, Abrams, Jansen and Shyrock: op. cit.
146 Committee on Cartography, A.S.P.G., op. cit.
with little apparent foundation. One rarely sees in the current literature even such comments as "Dr. Weise is not one of those geographic sinners who use any color for any step in a graded scheme of intensities. . . ."  

The loose criticism and the neglect of substantial color work in cartography would not be so serious if maps were actually problems in art, although as art their quality would be low indeed. As emphasized repeatedly, a map is a functional object and aesthetics is a by-product, occurring by chance if at all. On this assumption color work in cartography becomes of extreme importance because of its very significant physiological and psychological effects. That erroneous effects can easily be produced by deliberate color misuse has been clearly shown by Speier and Wright. Whether misuse is deliberate or merely the result of ignorance the effects are equally unfortunate. It is no accident that many German wall maps prior to the war and German propaganda maps during the war were better suited to their purpose than similar American products. The science of color vision has greatly expanded since 1900 and the physiological, physical, and psychological determinations of that period

provide a relatively sound basis for intelligent color work in cartography. Admittedly there is much, particularly in the psychological field, yet to be investigated but it is safe to assume they are but refinements of the principles already known.

Another of the fundamental problems of color in use which has plagued the scientific worker is the difficulty of color description or terminology. Until recently there has been no method of describing colors which reasonably matched the physicists descriptions of dominant wave length, purity, and brightness. However the Munsell, Ostwald, and Birren systems of color notation although not perfect provide the artist, cartographer, designer, and the general user of color with systematic and workable methods of color terminology. The Munsell system has recently been adopted by the Bureau of Plant Industry to describe soil colors. With it one may describe precisely the value and the intensity of a color although the terms for hue description are less exact.

Paralleling the development of the science of color vision, the techniques of color reproduction and color appli-


cation have made remarkable strides in recent years. Probably no single technique has given greater potentialities to the field of cartography than the air brush. This technique, barely fifty years old counting the first crude mechanisms of the early 1890's, allows the smooth application of continuous tones by the cartographer on copy, an operation formerly difficult except for the highly skilled. In the field of lithography and other reproduction processes advances in technical procedure have been equally rapid. At the present time it is possible to reproduce practically any kind of cartographic copy. Unfortunately, as the techniques and scientific knowledge have increased, so has the cost. As a result of the costliness of color production it is to be expected that the techniques for black and white cartography will be correspondingly better investigated and utilized. However, there will no doubt be little drop in costs of commercial color reproduction and although the majority of cartographers will not have the opportunity to assist in such undertakings they should be familiar with the bases for evaluating the methodology used thereon. Familiarity

At the present time costs are extremely high. This is due in part to production costs, but is likely more influenced by the lack of competition in the greatly understaffed and underequipped printing industry. A rough rule of thumb in estimation of costs of map printing is that each line color printing on a map costs the same as another map in one color.
with the methodologic principles will also enable the cartographer to make an intelligent choice of the available alternatives when economic considerations preclude the use of the ideal. For example a range of shades or tints may be produced from a single plate whereas the best range would involve the use of several plates. The choice of which particular hue to use then depends on the characteristics of hue perception and the purpose of the map.

The evaluation of color methodology must be based on the characteristics of color vision. If one were interested in the production of color he would necessarily need to be quite as familiar with the chemical and physical laws relating to color as light and color as pigment. A reasonable knowledge of these matters is necessary to the understanding of color vision, but:

"In addition to this the designer and user of color must be able to anticipate the often surprising action of color as the eye sees it, which is loosely called 'the psychology of color'. He must realize that a color which satisfies the chemist's and the physicist's standards may not be satisfactory as the eye sees it either for the purpose for which it must be used, or the manner in which it is to be used."

When color is examined from the point of view of its effect on the observer it has several characteristics. To the eye color varies as to hue, that is to say green differs from red. This is analogous to the dominant wave length of the physicist. Because of the structure of the human eye and the differing wave lengths of light, human vision reacts in different ways to different spectral hues. A knowledge of these differences is necessary to the proper employment of colors. Secondly, each individual spectral hue varies both in terms of its inherent brightness or value and in the degree of saturation or intensity of the color area. Just as the eye reacts differently to the various spectral hues so does it have varying sensitivity to value and intensity changes. Color always appears in an environment, which environment has a marked influence on its appearance. A significant although less important aspect of color methodology concerns the conventions, preferences, and the traditional significance of colors. The cartographer must be familiar with all these considerations before he can effectively evaluate the methodology of color. He must also have some background in the basic elements of color vision and color science.
Color vision

Color is the visual sensation produced by certain wave lengths of light. As is well known, the visible portion of the spectrum is relatively small and ranges from the short-wave violet to the long-wave red. The wave length of the visible violets is somewhat greater than 400 millimicrons while the long-wave reds are less than 700 millimicrons. Between these two extremes occur all the pure hues in combination producing white, but, of course, excluding black which is the absence of light.

It is fundamental to the consideration of color that it be clearly understood that for practical purposes color exists only in the eye of the observer. The physics of light is of importance in the investigation of the characteristics of color behavior and its findings provide a solid foundation for the discussion and analysis of color perception. But the study of color whether in cartographic methodology or in any other aspect of its use is based fundamentally not on the physics of light but on the sensations produced by the eye's reaction to colors.

One of the greatest difficulties connected with the study of color as a sensation is found in the description of colors. All who have tried to describe colors have experienced great difficulty in finding adequate words to express themselves, until Munsell and Ostwald placed color terminology on a consistent basis.
Colors vary as eye sensations according to hue, value, and intensity. Hue is the color itself, for example a red or a green. Value is the intrinsic brightness or darkness of a color, as for example, red is usually darker than yellow. The value scale ranges from black to white. Intensity is the term applied to the relative purity and amount of the color in a given area. This is expressed as a measure of the purity of the color compared to a neutral grey of the same value as the most intense expression of hue under consideration. Thus a full scale of intensities would range from the hue on one end to a neutral grey on the other. At no place would it vary in value. The scale of values is the simplest of the scales and is usually considered as a scale of ten divisions with black being the lowest in value to white at the highest. The intensity scale is more complicated. In the Munsell notation system the brightest red capable of being produced was considered as being ten steps away from neutral grey of the same value. This series established the intensity scale. It is interesting to note that since Munsell established this scale the ability to produce more brilliant colors has necessitated the extension of the intensity scale four steps beyond the original ten.

The description of hues is by far the most complex aspect of color notation because the possibilities of color combinations are infinite and because of the conflict of the physical and psychological methods. The physicist describes a color in terms of its dominant wave length, the extent to which it stimulates the red, green, and blue sensitive nerves, its brightness (value) and its purity (intensity). Unfortunately the comparison and matching of colors and most other color sensations are not systematically stimulated by colors according to wave length, etc., and it is necessary in the use of color that a system of color description be devised based on visual experience. Working on this basis Munsell chose the four basic hues, red, yellow, green, and blue, and, together with purple, arranged them around a circle. Between each pair of the above colors he placed the intermediate hues thus giving a hue circuit in which each hue is diametrically opposite its complement. Each hue is varied in terms of value in one dimension and intensity in the other. (Fig. 32)

Although Munsell’s notation system has received wide acclaim in the United States it has been improved upon by Ostwald and Birren who have shown that, from the point


154 Faber Birren: Color Dimensions, Chicago, 1934.
Fig. 32. The Munsell color tree. The hues radiate from the axis. They vary in value vertically and in intensity horizontally.
(From Faber Birren: The Story of Color, Westport, Conn., 1941, p. 249.)

of view of the user of color, Munsell's system does not supply adequate understanding of harmony relationships. First Ostwald and later Birren showed that all colors seen by the eye were derivatives of pure hue, black and white, and were

155 For a clearer analysis of the various color notation systems and their basis in color sensation see Faber Birren: The Story of Color, Westport, Conn., 1941, pp. 237-256.
susceptible of being given meaningful equations. These developments are of particular importance in providing the basis for color harmony and should be of great interest to the cartographer. It is impossible in this study to enter into the laws and principles of harmony, per se. As pointed out earlier cartographic methodology is less concerned with the creation of aesthetically pleasing compositions than it is with the problems of clarity and design, in the sense of appropriate representation. For the purpose of examining the bases for the evaluation of cartographic methodology it is sufficient that it be established that colors vary in terms of hue, value, and intensity. Ostwald showed, however, that from the visual point of view "white and black were colors just as much as were red or green". This is fundamental to the understanding of color methodology and is one of the most significant aspects wherein Eckert and the other writers on color in cartography failed in their efforts to establish sound bases. As a matter of fact, the earlier writers and users of color in cartography had to depend for their logic primarily on the research of the physicists, less on that of the physiologist, and hardly at all on that of the psychologist. The realization that color in use

156 Birren: Story of Color, op. cit., p. 255.

should be considered primarily as a sensation came only later. Thus the early emergence of the convention of representing elevation according to the arrangement of the spectrum lacks foundation in visual logic.

The fact that the eye distinguishes colors in terms of hue, value, and intensity does not complete these aspects of color vision of importance to cartography. It has long been known that although a color may be physically determinable by reference to spectrophotometry or to a color tree or color solid, its visual character depends upon its environment. The well known phenomenon of simultaneous contrast occurring when dark and light areas are juxtaposed is a simple illustration. The behavior of color vision with respect to environment is of considerable importance in the logical construction of maps.

Hue or spectral sensitivity

It is difficult to generalize concerning hue or spectral sensitivity because the investigations so far deal primarily with sensitivity of the eye to purely spectral hues and largely disregard the effects of hue combination. The results of various experiments regarding spectral sensitivity reported by Luckiesh are not entirely in agreement but they

strongly indicate that the eye is not ordinarily sensitive to changes of less than approximately 10 millimicrons. This would mean that there would be less than thirty spectral hues normally identifiable by the average eye. It is likely that the average untrained person can see considerably fewer. Notwithstanding that such data are of great interest in that it indicates that the untrained eye is not particularly sensitive to changes in hue, the available data do not provide bases for judging the sensitivity of the eye to combinations of hues, the most common hue sensations. It should be possible, using spectrophotometric methods, to arrive at a distinguishable interval for variations in hue. Birren points out that, while probably at the very maximum not more than 900 or 1000 colors may be seen by the eye, our vocabulary for color is very small. In general the available data would seem to indicate that choice of colors for cartography should be made with full realization that the untrained eye does not have much ability to distinguish between colors, and that the farther hues can be separated (without destroying any required unity) the better.


The eye is definitely more sensitive to some hues than to others. All observers agree that the eye is most sensitive to red followed by green, yellow, blue, and purple, in that order. This series provides the cartographer with a partial basis for choice of color depending upon how much emphasis is desired for the data to be represented by a color. Unfortunately no satisfactory data seem to exist which make it possible to grade the colors according to relative degree of sensitivity. A study by Fere commented upon by Luckiesh seems to indicate that red has nearly twice the effect of blue on muscular activity.

In the study of the sensitivity of the eye to hues it is well to remember that spectral hues vary in terms of brightness which in turn is of considerable significance with respect to the visibility of data because of contrast possibilities. The relative luminosity of the spectrum for the normal eye has been determined and of course is highest in the yellow-green region (555 millimicrons) and falls to approximately half its maximum within a range of 50 each way. Disregard of this obvious relationship through blind


162 It should be borne in mind constantly that with respect to color, as with all visual phenomena, all aspects are interrelated so that no single physiological or psychological phenomenon provides the sole basis for choice. This fundamental principle should precede every discussion.


subservience to the "logic" of the progression of the spectrum has led to many incongruities in map making. Although the effect is primarily due to value differences it is pointed out here as a good example of the interdependence of the various aspects of color in use. In many atlases, on the International Map, on many small wall maps, and in many other cases where colors have been chosen for hypsometric shading of altitude, the spectrum has been used as the basis. The lower altitudes have been shown in greens, followed by yellows for the intermediate altitudes and then reds or near reds for the higher. Because of the relative luminosity of the spectrum, by far the lightest areas, and by comparison the most visible, are therefore the areas of intermediate altitude which are rarely the areas of great importance. The indiscriminate use of yellow and its unfortunate effect in juxtaposition with other colors is well shown in the series of special maps in the Encyclopaedia Britannica Atlas.

Of minor interest in cartographic methodology is the phenomenon of the shift of spectral sensitivity with changes in illumination. With a decrease of illumination the maximum of the luminosity curve shifts toward the shorter wave lengths. In other words if a red and blue area are of equal

165 Encyclopaedia Britannica: op. cit., pp. 3F-3Q.
value at a high illumination, the blue surface will be higher in value at a lower illumination. Consequently it is logical that maps should be constructed, in so far as possible, for the illumination in which they will be used.

It is a well known fact that some colors appear more individual than others. For example, red is red but orange seems to be composed of both red and yellow. Many colors are named for the apparent combination, such as yellowish-green, greenish-blue, and blue-violet. Normally only blue, green, yellow, red, white, and black appear as individual colors. The reason for this is not definitely known but nevertheless all authorities agree that the phenomena of "pure hues" together with the "intermediate hues" are of considerable significance in color use. Their importance in cartography for showing interrelationship is obvious.

One of the peculiarities of hue sensitivity which has been of great interest to cartographers is the phenomenon of the stereoscopic effect of colors. Much of Peucker's theories of land form representation and particularly his "adaptive-spectral color scale" is based on the principle of advancing and retreating colors. The advance of the warm

166 Cf. Walter Sargent: The Enjoyment and Use of Color, New York, 1923, p. 44.


168 See Eckert: Kartenwissenschaft (I), op. cit., pp. 625-639, especially 631-634.
colors and the retreat of the cool colors may be due partially to the sum of experience in that warm colors are generally those of light while the cool are those of shadow. The major cause, however, of this sensation, long known, lies in the structure of the eye and the fact that light waves are refracted when they enter the eye. Rays are bent in inverse relation to their wave length, red rays being refracted least and blue most. The greater the refraction the farther away relatively the color seems. If the lens of the eye did not compensate for the differences in refraction the warm hues would tend to focus behind the retina and the cool in front. The compensation of the lens draws the color nearer or pushes it back. Although this phenomenon has been given great emphasis in cartography as previously noted in hypsometric shading and terrain rendering, too much emphasis on any one aspect of color sensation, even though logical, is likely to produce undesirable results. The stereoscopic effect of color is not as strong a factor as the sum of sensations as, for example, are value differences, and therefore, although advancing and retreating colors can aid in creating an impression it is doubtful if they can alone produce a desired effect in cartography. This was well appreciated by Peucker

169 Sargent; op. cit., p. 55.

and his colleagues. On the other hand, this effect can be very detrimental if ignored as, for example, in the case of red boundaries or warm areas not "lying down on the map".

One of the most important of the effects of variation in hue sensitivity is that associated with differences in visual acuity. It has long been known that monochromatic light is superior in defining power to mixed light and colors. In several tests Luckiesh found results which demonstrated the superiority of monochromatic light and found yellow to be superior to other colors in defining power. Value was held constant. He also showed that the distinguishing of fine detail was markedly easier under monochromatic light even though value contrasts were somewhat lower. For distinguishing fine black lines, yellow was about 35 per cent more efficient than blue, whereas there was somewhat less range between yellow and red. Unfortunately other tests confuse hue and value. It would seem safe to conclude that nearly any hue which did not mix wave lengths too far apart would be reasonably efficient in defining power. Although chromatic aberration is of significance in visual acuity, value contrast seems to be more important.

171 Eickert: Kartenwissenschaft (I), op. cit., p. 625 ff.
Value Sensitivity

It is not wise to single out any one component of design and place thereon the greatest emphasis since the possibilities of combination and the variety of utility are so great that in any one design some other component may dominate. Nevertheless, it is likely that, everything considered, no element assumes as great a role in design as does the interplay of light and dark (value difference). It is difficult to think of a map, which is anything like the ordinary, that does not have marked variations in value. Even the lettering exhibits value characteristics, not only as between the color of print and background as previously considered, but in the sense that a block of type or even a single word acts as a value area. (Fig. 33). Value, or brightness as the physicist calls it, is the second of the sensations which the eye receives simultaneously, the others being hue and intensity. So far as is known there has been no direct comparison of the relative significance of the three aspects of sensation, but there seems to be little doubt that value assumes greater importance in vision

Many factors enter into the choice of a type face besides legibility. One of the most important is weight or color. Some faces print light and some print dark; between the extremes of very light and very dark there are infinite variations of tone. Tonal value or intensity can be controlled by choice of type face and by leading; the more lead between lines of type, the lighter in type. "Old Style Italics"

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Fig. 33. Type color. Variations in the value effects of some different types.
(From Lopatecki: "Type Color", op. cit., p. 331.)
than either hue or intensity.

Value, as an element of vision, is of most significance when it enters into the application of contrast and will be considered below as an aspect of the effect of environment. There are, however, certain fundamental relationships in connection with the sensitivity of the eye to value not entirely based upon contrast effects.

The sensitivity of the eye to value differences is greatest over a wide range but the sensitivity decreases as both extremely high and extremely low values are approached. In other words, the eye requires greater differences in value near the black and near the white for a change to be noted. Of somewhat more significance in application, however, is the fact that with decreasing values the sensitivity diminishes more rapidly for colors of longer wave length than for shorter. It is necessary, therefore, to make greater value differences in the lower value scale for red than for blue. Both of the foregoing phenomena are of minor importance insofar as cartography is concerned since, generally speaking, value differences in cartography are not likely to be so slight that such difference in sensitivity need be operative. Of much greater significance is the magnitude of the value change which is easily visible under normal illumination.

\[175\text{ Luckiesh: Color and its Applications, op. cit., p. 720.}\]

\[176\text{ Ibid.}\]
Sargent points out that "... without training, our eyes perceive easily about five degrees of value beginning with white and ending with black". He goes on to say that with training one can recognize about ten graduations. Munsell chose ten with white and black at each end. Ostwald chose eight steps including black and white. Tone (value) densities in lithography and photography are usually limited to ten. It is apparent from both experimentation and from experience that the recognition of values is relatively difficult and that six to eight steps from white to black is about the maximum for eyes with some training. To be sure, the specialist can recognize more, perhaps many times more, but for methodological purposes in cartography six or eight values in addition to black and white are the limit.

One of the basic laws of vision, and particularly significant in connection with value, is the so-called Fechner or Weber-Fechner law. This law may be simply stated that in vision the sensation produced by an increase in stimulation bears a constant ratio to the total preceding stimulation. It is obvious that a value visually midway

177 Sargent: op. cit., p. 62.

178 See John Frederick Dashiell: Fundamentals of Objective Psychology, Cambridge, Mass., 1928, p. 115. The formula is given as $S = K \log R$ where $S$ is Sensation, $R$ is the intensity of the stimulus, and $K$ is a constant. The limits of $K$ are $1/65 - 1/195$ with $1/100$ being commonly assigned. The law is of fundamental importance in cartographic methodology for it is operative for any visual stimuli be they lines, shapes, or areas.
between black and white will not be composed of half white and half black but rather of much more black than white. The application of this principle to cartographic methodology is twofold. Its first significance is in the employment of contrast and it indicates that value contrast intervals must be based on sensation characteristics and not on simple arithmetical ratios. Secondly, it is of fundamental importance in the field of statistical representation since value sensations will not be accurate in a scheme of simple areal distribution if the effects depend upon arithmetic relationship.

Another principle of value sensitivity is that an extreme value, especially either white or black, tends to dominate a composition. Sargent points out that because of this characteristic of extreme values "Large areas of both black and white... are seldom pleasing". A great many maps, particularly specialty maps, are today made with the basic value relationship being black water and white land. Since it appears that extreme value changes of large areas...

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181 Sargent: op. cit., pp. 70-71.
are likely to be fatiguing this practice is of questionable merit. The probable explanation of this phenomenon of fatigue is involved but it may be connected with the fact that in practice black seems to be associated with the long wave end of the spectrum and white with the short end.

In the studies of color of print and background black on yellow seems to be preferable from the point of view of visibility (although not for books and general reading) because it is less fatiguing than black and white contrasts.

Intensity Sensitivity

The sensitivity of the eye to changes in intensity has not been so well studied as has its sensitivity to value or hue. Studies summarized by Luckiesh seem to indicate that the eye is less sensitive to intensity than to either of the other primary sensations. The just perceptible variations in intensity vary with hue and with value. The Munsell color tree clearly shows that the distinguishing of intensity variations is greatest in the middle values and falls off at each end of the value scale. Studies made by Geissler,

182 Sargent: op. cit., pp. 72-74.
interpreted by Luckiesh, apparently indicate that the intensity discrimination at equal values required a greater increment for the middle colors of the spectrum than for those at either end.

Effect of Environment on Color Appearance

Environment of color may, in general, be considered as having more bearing on cartographic methodology than intensity sensitivity and of equal importance with hue and value sensitivity. Within the broad methodology of color it assumes approximately the same degree of importance as contrast does in structural methodology. In a sense color always has an environment and the foregoing discussion of the sensitivity of the eye to hue, value, and intensity, is somewhat theoretical in many of its aspects. For example value appearances will be markedly different depending upon environment, and the recognition of a true middle value between black and white is difficult, if not impossible, under contrasting environments. Were it not for the effect of environment in modifying color sensations the methodology of map color would be relatively straight-forward and would be capable of generally objective treatment. The


186 Ibid., p. 175.
principles enumerated in the above section are all capable of measurement and many have been carried to a point where prediction of effect is quite possible. The effects of environment, however, make it necessary to place in the background some of these principles and the actual methodology of color must be based as much on empirical methods as on scientific data. It is entirely possible with sufficient testing and experience that in the future even the facts of sensitivity to environmental conditions will be capable of exact determination.

The influence of environment on color sensation may be divided into two general categories, the first having to do with the effects of varying the physical conditions of viewing a color and the second, and more important, concerned with the contrast effects of hues, values, and intensities. The importance of the latter is but another illustration of the importance in cartographic methodology of visual contrast.

A phenomenon which has not received much study is that associated with the changes in appearance of a colored area with variations in its size and position on the retina. For example, on a map of languages in the Encyclopaedia Britannica World Atlas, Mexico and Hispaniola are both tinted the same color, but Mexico seems to have a considerably

greater intensity than does Hispaniola. Studies by MacDougall commented upon by Luckiesh indicated that size of area has a definite effect on apparent intensity and that the variations were greatest for the short wave end of the spectrum and decreased steadily toward the long wave region. It is apparent that when various colors are to be used to differentiate both large and small areas, changes in hue are more satisfactory than changes in intensity and value.

As already noted variations in illumination cause a shift in apparent hue of colors, and colors appear more saturated at low than at high illumination. Of much more significance however is the fact that the quality of light determines the appearance of colors, and hues arrived at under artificial light may or may not appear the same under daylight. When combinations of colors are to be used on a map it is of importance to consider their appearance under the illumination in which they will be used.

Although the phenomenon of after image is interesting and striking demonstrations are possible it is doubtful if this effect is of more than passing interest in cartography. However the phenomenon known as simultaneous contrast, dependent in part on after image effects, is of importance in planning a colored map. Simultaneous contrast is the sensa-

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tion occurring when different colors, values, or intensities, lie adjacent to one another, a common occurrence in cartography. Complementary or near complementary colors when in juxtaposition enhance the intensity of one another. As a consequence colors which are not particularly strong when viewed by themselves may be unduly brilliant when placed side by side. Doubtless this accounts in part for the unusual brilliance of some of the earlier state maps of the United States in which the states appeared in violently contrasting colors.

Perhaps the most common effects produced by simultaneous contrast are those involving value differences. Although the sensation so produced shows up in a number of ways it is basically a simple relationship. The greater the value contrast the greater the apparent value difference. This has been demonstrated many times. The effects of simultaneous contrast are especially noticeable in maps employing gradations of value for progressive categories of data such as annual rainfall or population density. A special form of simultaneous contrast often occurs when the values are placed next to one another in a legend. This gives rise to a phenomenon, known as induction, wherein the edge of an area of lighter value

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190 e.g. Luckiesh: ibid., p. 174; and International Printing Ink Corp.: Mon. II, op. cit., p. 11.
that is adjacent to an area of darker value will appear lighter than the other edge, especially if it is adjacent to an even lighter area. Consequently, the recognition of values is made difficult and great confusion will result if the effect of induction is also present on the map.

Fig. 34. Induction. Each gray patch is of uniform value, but the adjacent value modifies its appearance. (From an Eastman gray scale.)

There are many other ways in which simultaneous contrast affects the character of colors most of which are of lesser importance in cartography. Hue, value and intensity singly or any combination of them can be made to appear differently according to background. The effects of simultaneous

191 Luckiesh: Color and its Applications, op. cit., p. 175.

192 Good examples are given in International Printing Ink Corp: Mon. III, op. cit., p. 11.
contrast, including induction, are largely eliminated if the contrasting areas are separated or if the areas are outlined in black.

Another significant phenomenon caused by simultaneous contrast is the apparent increase in size of areas or lines as they are increased in brightness. Although there have been a number of tests of the effect of hue on the apparent size of objects, none of them seems to have gone far enough to derive any mathematical relationships. They all show that light objects seem larger and dark, smaller. Hue apparently has little effect.

**Color convention and preference**

It is a common practice in cartography to justify the use of color on maps by the logic of association with the thing mapped. Thus the ocean is blue, lowlands (European!) are green, red is for high temperatures, blue, purple, and white are cold, soil is brown, and many others. The super-systematic German mind enjoys the logic of color association and the extremes to which it can be carried is well illustrated by the following quotation from Eckert:

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"An interesting and logical use of colors is shown by the maps belonging to the field of medicine and which were produced for the first time at the beginning of this century by Rossle. On a panoramic map of Germany he presented the spread and frequency of occurrence of dangerous illnesses. For tuberculosis he chose blue; the diseased lung looks gray-blue. Blue, for cartographical and statistical representation of tuberculosis, has already reached international meaning in the world of medicine. For the spread of child diseases, such as scarlet fever and measles the red color was chosen; typhus, characterized by its dark brown bowel movement, is painted dark brown, and cholera is shown with yellow-brown colors." 196

The use of the spectral hues in the order in which they appear is strongly entrenched in cartography, not only for hypsometric shadings, but for other gradations of data as well. Eckert, however, was quite open-minded and pointed out that perhaps other systems might be preferable for he refers to the possibility of using the Ostwald "color circle" and states that "Up till now 1938 no attempts have been made to use the color circle in cartography" and "I have great faith in it." 198

There seems to be little reason to believe that cartographic methodology will not ultimately leave behind its

196 Eckert-Greifendorff: op. cit., pp. 41-42.
197 Ibid., pp. 42-43.
198 Ibid., p. 43.
dependence on the early physical and physiological researches in color and advance toward the utilization of the research of the psychologists and others investigating the effects of color as a sensation of the human eye.

This does by no means require the discard of all color conventions. Red and blue stand at the top of the list of color preferences. Red is warm and blue is cool in traditional significance although a study by Morgansen and English seemed to show opposite results. The traditional significance and appropriateness of colors is a subject about which much has been written and many of the theories are somewhat in conflict.

A large number of psychological studies have been made in the field of the significance of color and more especially in connection with color preference.

Although the results of these tests are not conclusive they tend to suggest safe limits for the methodology of color choice.


Summary

In general, the evidence and logic is preponderantly in favor of basing the methodology of map color on the fact that color as it affects the human eye is primarily a sensation the ramifications of which bear little logical relation to the arrangement of hues and brightness in the spectrum. Out of the extreme complexities of the sensations of color, the one sensation the variations of which appear to be most effective in presentation seems to be that of value contrast. The other aspects of color methodology although of less general significance may be of extreme importance in special cases and contribute significantly to the development of clear, unequivocal, and legible cartography. The more significant of these characteristics of color vision which constitute the bases for the methodology of map color are as follows:

1. Hue sensitivity.
   a. The eye is not particularly sensitive to changes in hue.
   b. The eye is most sensitive to red, followed by green, yellow, blue, and purple.
   c. Spectral luminosity varies greatly and has an important effect on visibility.
   d. Hue sensitivity varies with illumination.
   e. Some hues appear more individual than others.
   f. Warm hues advance, cool hues retreat.
g. Visual acuity varies with hues.

2. Value sensitivity.
   a. Changes in value are more important than changes in either hue or intensity.
   b. Sensitivity to value change is greatest in the middle of the scale and falls off at each end.
   c. Sensitivity to value change in the lower values is greater for the longer wave length hues.
   d. The maximum number of steps in the value scale which can be recognized with some training is ten. The average person can recognize considerably fewer.
   e. The Weber-Fechner relationship is fundamental to value relationships.
   f. Extreme values tend to dominate a composition.

3. Intensity sensitivity.
   a. Intensity of colors is of less significance than either value or hue.
   b. Intensity discrimination is greatest in the middle values, and toward each end of the spectrum.

4. Effect of environment on color appearance.
   a. Environment is of equal importance with value and hue sensitivity.
   b. An increase in area is accompanied by an increase in apparent intensity.
   c. The change in apparent intensity is greatest for the short wave end of the spectrum.
d. Quality of illumination determines appearance of hue.

e. Simultaneous contrast enhances the apparent intensity of colors.

f. The greater the value contrast the greater the apparent value difference.

g. Separation or outlining in black eliminates the effects of simultaneous contrast.

h. Areas or objects of high value seem larger than the same areas or objects of lower value.

5. Color convention and preference.

a. Color conventions are extreme in cartographic methodology and are likely to be based on association, not visual logic.

b. Those based on color science are not based on modern developments.

c. Color preference and traditional significance provide a minor basis for color choice.
CHAPTER V

CONCLUSION

In the years to come it is likely that the 20th Century may be designated the golden era of cartography. The field once before experienced what amounted to a renaissance and reformation from the traditions originally established by the Greeks, and the current rapid development may be a second reformation, this time from the conventions established prior to the growing acceptance of functional design as the basis of creative effort. That this philosophy has not yet been generally recognized by cartographers is probably not due to any inherent conservatism in the field but rather to their inability to find time for research along the lines of visual perception.

Until very recently cartography has suffered from lack of recognition as an academic subject. Although geographers and geography departments in the Universities of the United States have long considered maps the prime tools of their discipline neither they nor their administrative superiors considered it worthy of more than minimum support. Research in techniques languished until recent years. The Europeans, especially the English and the Germans, have devoted more
effort to the technical aspects. Max Eckert, the great German cartographer, is the only writer of the era to examine exhaustively the bases of cartographic methodology. His concept of the "science of cartography" is somewhat confused partly as a result of the fact that he wrote it before the trend toward functional design had progressed far and partly because much of the investigative work in allied fields had not yet been carried out or was only in its early stages.

Considerable analysis of certain concepts in the methodology have been made both in this country and abroad but they deal primarily with aspects substantive in nature. For example, studies concerning the representation of slope, population, and other distributional facts are devoted first to methods of deriving the information, and second with techniques of resolving the data into such form as can be presented graphically. The analysis of the presentational strength or weakness of the techniques when included has been usually only incidental, and it commonly has been ignored completely. Presentation in graphic form is dependent upon the use of basic visual techniques such as lines, shapes, letters, colors, shading, position, and a variety of visual media. An analysis of the value of the substantive techniques cannot be definitive unless there exists a set of principles derived by evaluating these basic visual techniques. There is no way of determining the effec-
tiveness of capital letters of various sizes as symbols for mineral distribution until the characteristics required of point symbols have been catalogued. The latter cannot be accomplished with any degree of success until the underlying bases have been determined and evaluated without the confusion accompanying intellectual connotation.

This study attempts to analyse the visual characteristics of cartographic methodology in their most elemental aspects. The visual methodology arranges itself under three general headings, lettering, structure, and color. Each of these subjects has been investigated for the purpose of analysing its inherent characteristics as they are manifested in cartography. The results of the investigation indicate that heretofore cartographic methodology has been in general haphazardly conceived, or where bases are in evidence they have not been derived with sufficient regard for the characteristics of vision.

The research in color science and experimental psychology and aesthetics presents evidence that many of the concepts and procedures of cartography need revision. For example, studies in the perception of print show that legibility and perceptibility of type is a complex problem. It varies according to the form of the type face, its size, orientation, and color. Although in the cartographic literature there are many opinions and generalizations concerning legi-
bility and perceptibility they are neither consistent nor based on evidence. Not only does the experimental evidence give cartography a series of bases for the functional employment of type, it also provides the necessary groundwork for studies of type design and use for exclusively cartographic purposes.

Experimental evidence and painstaking analysis in the field of color science also provides cartography with methodological bases heretofore lacking. Without a doubt the most important of these is the fact that the arrangement of the spectrum has little or no relation to the sensations of color. The evidence also suggests that value contrast seems to be the most effective of the many complex color sensations. The temptation is great to argue that the current categorical division of maps into either black and white or colored is not so significant, so far as legibility is concerned, as would be a distinction based on value contrasts. The various characteristics of hue, value, and intensity sensitivity of the eye and the effect of environment on color appearance developed in the study of color as a sensation provide the cartographer with a solid foundation for his methodological procedures. To be sure, in a great number of cases a cartographer, for economic or other reasons, will be unable to carry out the methodology to his entire satisfaction. The characteristics of color vision, however, provide him with
bases for intelligent choice of less desirable alternatives.

The least precise of the methodologic aspects is that of structure. On the other hand the element of projections and their use seems to have inherent qualities which lend themselves to quantitative study and it is likely that further investigation along the lines suggested by Tissot and Hinks will lead to valuable results. The experimental study of contrast in shapes, lines, and areas used in cartography has scarcely been undertaken as yet. When the results of much experimentation become available they will provide cartographers with a reasonable basis for choice. Generally speaking, such bases are now lacking.

The methodologic bases for cartography are largely dependent, at present, upon the research done in other fields. Although this research is not directly applicable to cartographic procedure it provides the necessary groundwork. Whether the experience of related fields will be utilized and developed in cartography remains to be seen.

The following three examples (Figs. 35, 36, 37) illustrate maps which have been prepared with due regard for the principles of lettering, structure, and color. Figure 35 was designed to illustrate the progressive westward territorial acquisitions of the Russians. Since the number of shadings required was too large to provide clear recognition solely on a value basis, distinctive pattern was included.
Fig. 35. Use of pattern and value.
(From Vera Michele Dean: op. cit., p. 25.)
Because none of the areas was clearly of dominating interest no extremes of value were employed. Areas of primary interest were those which had been acquired and later "lost" by the Russians. Consequently, those areas were made the highest value. Unfortunately, size and printing stock specifications required a smaller scale and a coarser treatment than would have been desirable.

Figure 36 illustrates a clear approach to a complicated problem. The distinctive shape clearly defines and focuses attention on the limited area under consideration. The high value contrast and the absence of nonessential base data clearly emphasizes the significant subject matter.

Figure 37 is a well-designed map. There is no doubt as to the distribution of land and water. The lighter outlining of the islands in the Golfe di Trieste prevents the area from assuming undue visual importance because of visual complexity. The legend, important in this map, is clear from a glance because of the outline of blue, its geometric shape, and the high value contrasts within the box. The three lines of interest on the map are clearly distinctive in pattern and are much higher in value than other line work on the map. The lettering is all related in form and thus no attention is wasted on discrepancies. Sizes, and thus relative perceptibility, are clearly related to the function of the map to such a degree that although there are at least ninety or
Fig. 36. Use of distinctive shape and high value contrast. (From Population Changes and their Significance in New York and its Environs, Regional Plan Bull. No. 55, New York, 1941, reproduced in the Geogr. Rev., Vol. 36, 1946, p. 390. Reduced.)
a hundred words on the map it does in no way appear over-
loaded.

The placing of methodology on analytical and experi-
mental bases may seem to suggest that creative interest is
thereby stifled. The use of such bases will not result in
stereotyped maps any more than adherence to established
principles has resulted in all advertising being in the same
pattern. The purposes and uses of maps are so varied and the
subject matter so infinite that it is improbable that the
field will develop many "standard procedures". Certainly
there will be some, but if cartographers develop a healthy
questioning attitude any such procedures will need to be
based on sound methodologic principles. Fresh ideas together
with new methods and combinations of techniques will maintain
the essential independence of the cartographer.
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VITA

I, Arthur Howard Robinson, was born in Montreal, Canada, January 5, 1915. I received my secondary school education in the McGuffey School at Oxford, Ohio, and my undergraduate education at Miami University, from which I obtained the degree Bachelor of Arts in 1936. I received my graduate training at the University of Wisconsin, from which I obtained the degree Master of Arts in 1938, and at The Ohio State University. While in residence at the University of Wisconsin and later at The Ohio State University I held teaching assistantships. In 1941 I withdrew from The Ohio State University and accepted a position with the Office of the Coordinator of Information which became the Office of Strategic Services. In the latter organization and later in the Department of State I held the position of Chief, Map Division, Research and Analysis Branch until I resigned as of January 1, 1946. During the eighteen months prior to my resignation I was a commissioned officer (Captain, Major) in the Army of the United States. Subsequent to my resignation from the Department of State I accepted a position as Assistant Professor of Geography at the University of Wisconsin. During the summers of 1946 and 1947 I carried on much of the research necessary
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