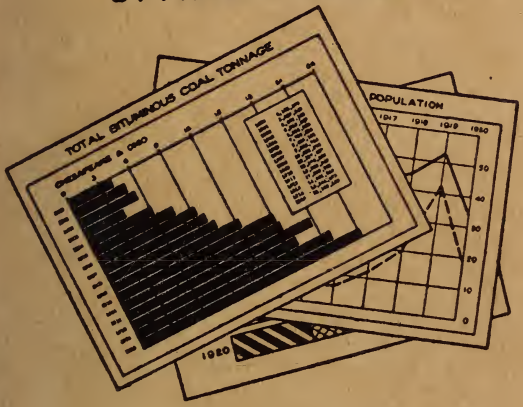
CHARTOGRAPHY
IN TEN LESSONS
BY FRANK J. WARNE



PUBLISHED BY
FRANK J. WARNE
SOUTHERN BUILDING
WASHINGTON, D.C.

CHARTOGRAPHY

IN TEN LESSONS

BY

FRANK J. WARNE

AUTHOR OF

WARNE'S BOOK OF CHARTS
WARNE'S ELEMENTARY COURSE IN
CHARTOGRAPHY, ETC.

ILLUSTRATIONS BY H. F. CHURCH

PUBLISHED BY

FRANK J. WARNE,
SOUTHERN BUILDING
WASHINGTON, D. C.

TABLE OF CONTENTS

LESSON III

The Curve Chart

LESSON IV

Features of a Complete Chart

LESSON V

The Bar Chart

PREFACE

No attempt is made in these ten Lessons to cover the entire field of chartography. To do so adequately would require several large volumes. All that these Lessons aim to do is to familiarize the student with the primary or elementary principles. These underlie chart plotting and construction as applied to the curve and bar charts. These principles are applicable to all kinds of charts, variations being explained by the differences in the circumstances surrounding the special problems.

These Lessons are the by-product of an experience covering a period of ten years during which time the author has been engaged professionally in the application of the principles of chartography to the working out of practical problems of the work-a-day world. In the presentation by means of diagrams or charts of innumerable statistical problems the author has been able to put the art of chartography to a severe test before such authoritative tribunals as the Interstate Commerce Commission, various state public utilities and railroad commissions, boards of arbitration appointed by the President of the United States for the peaceable settlement of labor contro-

versies and various committees of Congress. In this professional work he has been called upon to till entirely new fields, for there were few authoritative guides to follow, and in consequence he has been compelled to pioneer his way amid innumerable uncharted difficulties. Such an experience should contain lessons of value to others engaged and about to engage in the making of charts. In presenting this formulation of the principles of chartography the author begs leave to express the hope that these Lessons may serve the beginner in chartography as a safe guide over the innumerable pitfalls that inevitably must be encountered unless he is warned to guard himself against them.

An endeavor has been made to bring these Lessons within a reasonable price to the student. The cost of production of "Warne's Elementary Course in Chartography," which was published two years ago and the price of which was fifty dollars for the twenty Lessons (including "Warne's Book of Charts"), was such as to prohibit a lower price, and in consequence it could not be made to serve the class of students the author desired most to reach. Parts of that Course have been completely revised in these Lessons.

INTRODUCTION

The Value of Chartography

(Revised from "Warne's Elementary Course in Chartography" and "Warne's Book of Charts.")

To the average citizen statistics are as incomprehensible as a Chinese puzzle. To him they are a mental "Mystic Moorish Maze." He looks upon columns of figures with suspicion because he cannot understand them. Perhaps he has so often been misled by the wrong use of statistics or by the use of incorrect statistics that he has become sceptical of them as representing reliable evidence as to facts and, like an automaton, he mechanically repeats "while figures may not lie, all liars, figure," or the equally common libel, "there are three kinds of lies—lies, damn lies and statistics."

And yet statistics are an infallible indicator of economic conditions—they measure the heart-throbs of a nation's or of an industry's life-blood. They register the conditions of any given static situation; they point the direction of a trend or tendency with the accuracy of the thermometer in measuring the temperature.

Every business, whether organized on a large or a small scale needs statistics—in fact, statistics

are vital to its successful existence. Without them the executives cannot know the status or tendency of the economic factors which control their affairs. This practical value of statistics in every-day business life is coming to be more and more correctly appraised at its true worth. The *Railway Age* of February 23, 1917, says:

An officer of a western road recently made the statement that each department of a large railroad system should have on its staff a thoroughly competent man whose duty it should be to analyze statistics. The assertion was not made without deliberation, and it might be pertinent to ask whether we are getting the most out of the statistical department. The amounts which are spent by American railroads in compiling statistics bearing on the functions of the various departments are extremely large, and no one who knows the importance of the comparative figures to the officers will question the wisdom of the expenditure. Some of the statistical data which the railroads compile is readily analyzed, and the important figures, such as average tons per train, or pounds of coal per thousand gross ton-miles, are always readily available. A closer analysis of data which is regularly compiled would develop important facts which are not brought out in the routine reports. The head of a department may desire more information than that regularly furnished him, but he cannot take the time to get it himself, and a clerk could not understand its meaning or application, and would

overlook important points. Great stress is laid on the comparison of results for successive months, and the comparison with figures for the corresponding months of the previous year, but statistics are no less important as a means of forecasting results by comparing a proposed method with the one in practice. The great expenditure for statistics is relied upon to show the leaks and determine wasteful methods. The field of the statistician should be broadened and he should give more attention to the possibility of constructive activity. The statistical department has long been depended upon to keep costs from going up. It is time we recognize that it lies within its province to show how costs can be brought down.

Statistics have become a vital, every-day need not only in transportation but also in industries of all kinds, in finance, in journalism, in social work, in public life, and in business of every description. They are necessary to men of affairs, publicists, economists, and even to the average citizen if the significance of facts and the trend of events are to be comprehended. Virtually our entire political life, both state and national, is now regulated and its course determined by statistics. Every important branch of government has its statistical bureaus. Large financial institutions, industries, manufactories, railroads and other transportation companies have their

statistical departments. Innumerable associations must resort to statistics in order efficiently and effectively to carry on their work.

This recent growth in the demand for reliable statistics and their correct interpretation has suddenly raised the standing of the statistician to one of importance, and this has been accompanied by a corresponding increase in his remuneration. Today the openings for one versed in the fundamental laws of statistics—in their collection, compilation, presentation, and interpretation—are innumerable. The demand is greater than the supply.

The value of statistics, while great, is inestimably enhanced by the aid of chartography. It supplements statistics—it supplies the best known method for their presentation and interpretation. In all those phases of presentation which count for clearness and quickness of comprehension, no other method is equal to it. It makes clear at a glance, even to the uninformed and uninitiated, the significance and tendency of the factors that are portrayed. As nine-tenths of the problem in interpretation is clear presentation the value of the service rendered to statistics by chartography cannot be over-emphasized. Especially is this realized when it is remembered that statistics, to be useful and valuable, must

not only be accurately compiled but must also be correctly interpreted. Relatively, too much time is spent in the collection and assembling of statistical material and too little in its clear and forcible presentation. Here is where chartography becomes an invaluable handmaid to statistics.

The graphic presentation and interpretation of statistics as the basis of a recognition and an understanding of industrial, political, financial, social, economic, and other tendencies has become essential to practical men of affairs as well as to publicists, economists, and others. It can be made of incalculable value in any line or department of business—in that of finance, corporate relations, internal organization, traffic, supplies, production, prices, wages, costs, and scores of others. It not only will repay its cost but will be found of such great value in so many ways that, once instituted, it will never be abandoned. It will save in the time of the busy executive alone more than its cost, because it will enable him to analyze the facts and tendencies at a glance instead of spending hours in studying the relations of the figures in the different columns. It will make more certain the correct interpretation of the basal information necessary to action and the formulation of a successful policy. It will enlarge and extend his individual experience and

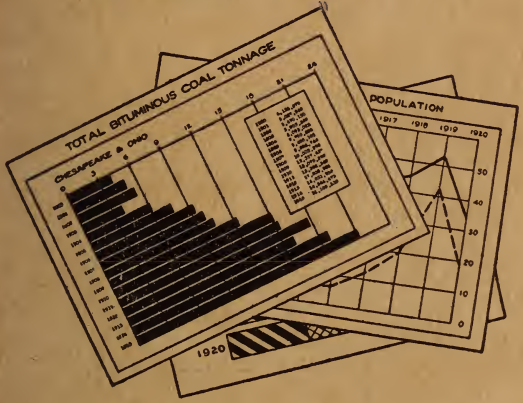
his accumulation of knowledge of the details and principles of his business. It will replace vagueness and indefiniteness by assurance and certainty, hazy conceptions will become clear-cut perspectives, and these in turn will lead to a comprehensive grasp of the entire problem.

The recent development in and the growing demand for diagrammatic statistics will continue, and he who masters the few simple yet fundamental laws or rules upon which it is based will be in a position to become an authority in his particular field and to command a comfortable income.

FRANK J. WARNE.

WASHINGTON, D. C.
October 1, 1919.

CHARTOGRAPHY
IN TEN LESSONS
BY FRANK J. WARNE



LESSON I — 10

BUILDING THE CHART

PUBLISHED BY
FRANK J. WARNE
SOUTHERN BUILDING
WASHINGTON, D. C.

LESSON I

Building the Chart

Value of Table of Contents—Statistics and Chartography—Definition of a Chart—The Statistics—Horizontal Lines—Vertical Lines—A Choice of Methods—The Use of Pencil Dots—The Framework.

In the Table of Contents preceding this Lesson has been given a comprehensive outline of the field the beginner in chartography is to cover in this and succeeding pages. It is a bird's-eye view of the course of study that has been mapped out for him in these Lessons. It should not be passed over lightly but should be studied seriously, for the reason that such a study will give to the student at the very outset a broad perspective of the problems he is to encounter and overcome.

Figuratively, he is starting on a mental journey, with its ups and downs, its delights and pleasures, its perplexities and obstacles—with a good deal of play and some hard work ahead. The Table of Contents is the itinerary, kept by one who has many times covered the same ground and who thus is able to point out the significance of

the things that are to be encountered. The student will benefit greatly in the mastery of these Lessons if he will frequently re-read the Contents.

VALUE OF TABLE OF CONTENTS

The Table of Contents can also be likened to a railroad map in the hands of one starting on a long journey. It enables him to traverse with his eyes the entire distance of the trip, noting the general characteristics of the country through which he is to pass, its mountains and rivers, and the principal cities along the way. Thus he secures, before he starts on the journey, a much better idea of where he is going and becomes more familiar with the country through which he passes than he would if he studied the railroad map piecemeal after the journey begins.

These ten Lessons will take the student on an intellectual trip in the course of which he will be called upon to exercise such mental traits as application, concentration, observation, and imagination in overcoming the various obstacles on his way to the acquisition of knowledge concerning the art of chartography. He cannot reach this desirable end without progressing step by step in mastering its various features. And at every step in this progress the broad view of his

final destination which he will have acquired by a close and frequent study of the Contents will be of material assistance to him. It will not only enable him to cover the ground much more quickly and with less exertion, but also with much more satisfaction to himself.

STATISTICS AND CHARTOGRAPHY

The value and usefulness of statistics and the relation to them of chartography, as well as the objects of chartography, have been pointed out in the Introduction. From a reading of those pages it should be plain that figures in tabular form, or which can easily be arranged in the form of a statistical table, are essential to the drawing of a chart—they are the reason for the chart being made.

DEFINITION OF A CHART

The drawing of a chart therefore presumes the existence of the statistics. It has nothing to do with their collection or compilation. A chart is merely a sheet of paper on which tabulated facts are presented graphically. It is also called a diagram or "graph." In a limited sense it can be likened to a moving picture, with this difference: In the case of the chart it is the eye and not the picture that moves.

THE STATISTICS

For the purpose of familiarizing the beginner with the various steps in the process of making the framework of a chart these figures are selected:

1913	1914	1915	1916	1917	1918	1919
26.7	26.7	26.4	28.1	38.2	49.5	57.2

The first line of figures represents calendar years and the second line the average retail price of a pound of bacon in the United States on April 15 of each specified year. This information is from page 77 of the Monthly Labor Review of the Bureau of Labor Statistics of the United States Department of Labor.

To make a chart from these figures is a simple proposition—as simple as the alphabet, that is, provided one knows the alphabet. It is as difficult to one who does not know how as the alphabet is to the child first beginning to lisp the letters. That which at first appears to be a very complicated and difficult thing to do comes to be surprisingly simple after one has acquired the necessary knowledge and facility. In the beginning all that is needed is a lead pencil, an ordinary ruler, and a blank sheet of paper.

HORIZONTAL LINES

A glance at the statistical table shows there

are seven prices to be recorded. These can be represented for the present by as many lines drawn with the lead pencil at equal distances apart from left to right across the blank sheet of paper. The result gives the lines A–A, B–B, C–C, D–D, E–E, F–F, and G–G on this page.

These are horizontal lines. It is important that the beginner bear this fact in mind. He should remember that a horizontal line always

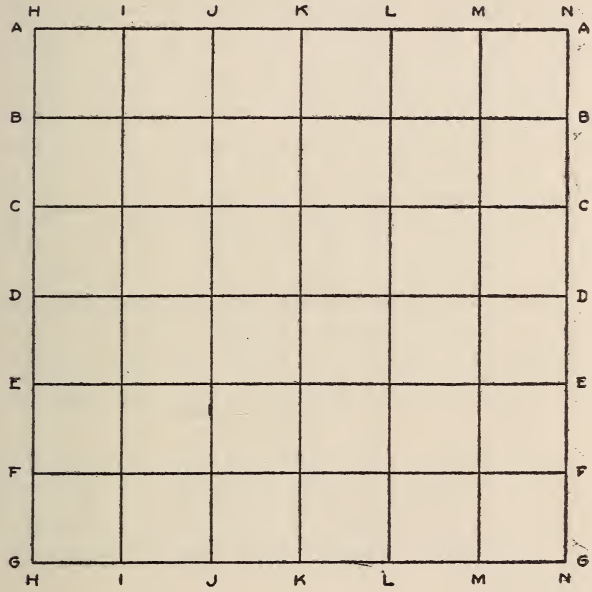
extends in the direction of the horizon, that is, parallel to the horizon. Here the horizon is represented by the top edge of the sheet. Horizontal lines are drawn from left to right, never from right to left.

VERTICAL LINES

In our statistical table we have another set of seven figures. These represent that number of years. So we mark off on the bottom horizontal line G–G, by means of the inch and its fractional units of the ruler, seven dots each an equal distance apart, the first dot starting at the beginning of the line on the left. These dots we repeat on the top horizontal line A–A. Next we draw seven vertical lines connecting these dots, beginning with the first dot on horizontal line G–G. Upon completion of the last vertical line erase the dots on the top and bottom horizontal lines.

Do not draw these vertical lines backward, that is, downward from line A–A to line G–G. A vertical line is an upright line, that is, it is directed perpendicularly to the plane of the horizon, as distinct from the horizontal line which, as has been said, is parallel to the horizon. These seven vertical lines we designate as H–H, I–I, J–J, K–K, L–L, M–M, and N–N. Superimposed on the seven horizontal lines these vertical

lines give the framework shown in the following drawing.



The distinction between horizontal and vertical lines should be clear to the student. The junction of a horizontal and a vertical line forms a right angle.

Another way to begin the erection of the framework of a chart, and one which will likely appeal more favorably to the student after he has acquired greater knowledge of the subject, is to draw first the horizontal lines G–G and A–A and then the vertical lines H–H and N–N. This gives the outline on the opposite page.

These four lines are the really important lines of a curve chart. In relative importance they are in this order: H–H, A–A, G–G, and N–N. The uses to which each is put the student will become more familiar with in subsequent Lessons. All that is necessary for him to know now is that:

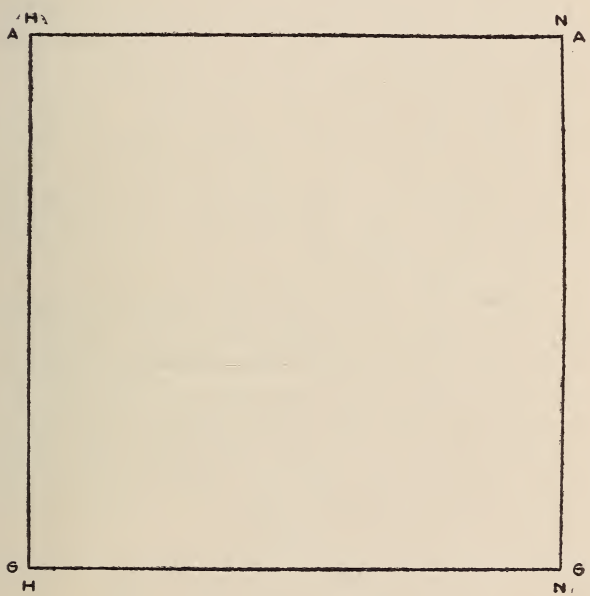
Line H–H is the vertical scale line and with its units of measurement virtually determines the distance the curve is to move. In other words, all movements of the curve are measured *by* this line.

Line A–A is the horizontal scale line, and in all curve charts involving elements of time it takes the time units. In our present problem as to the price of bacon it provides positions for the years.

Line G–G is the base line of the chart. Figuratively, it is the foundation line upon which all the vertical lines rest and from which they start. This base line is the zero of the vertical scale and, whenever possible, should always be indicated

by a cipher. All movements of the curve are measured *from* this line.

Line N–N is the least important of these four



lines, but this is not saying that it is not necessary and useful. Its functions will be pointed out to the student later.

THE USE OF PENCIL DOTS

With the four lines I have described already drawn on the sheet, the beginner next divides by dot markings the base line G–G into six equal spaces, starting the first of the five dots the distance of one space from the left end of the base line G–G and ending the dots the same distance from the right end of the base line. Duplicate these five dots at their respective distance apart on the top line A–A. Now connect these dots with vertical lines extending from the bottom to the top line. This gives the five lines I–I, J–J, K–K, L–L, and M–M.

Repeat the pencil dots with the same space between them on vertical lines H–H and N–N, beginning the first of the five dots the distance of one space from the bottom of lines H–H and N–N. Connecting these dots with horizontal lines gives the lines B–B, C–C, D–D, E–E, and F–F. Now erase all the dot markings. The result is the same as that shown on page 7.

THE FRAMEWORK OF THE CHART

This is the framework of the chart. It is the scaffolding by means of which the curve is to be erected or constructed. It is the skeleton structure for supporting the curve. Without it

the curve could not be constructed properly or correctly; neither could the curve adequately perform the service for which a chart is drawn. The lines will be found to occupy positions behind the curve, or rather to form a setting or background for it. The framework is essential for determining the movement of the curve and must be built up before the curve can be placed.

QUESTIONS FOR SELF-EXAMINATION

1. Describe the broad view of the field of chartography gained from a study of the Table of Contents. What service does this table perform for the student?

2. Describe the relation between chartography and statistics.

3. Of what value are statistics to business? To other activities? What is the service chartography performs?

4. Do these Lessons cover the entire field of chartography? Why?

5. Define a chart. What is a horizontal line? A vertical line? How is each drawn with a pencil?

6. What is the framework of a chart? How is it constructed?

7. What are the most important lines of the framework? Describe their uses.

8. Of what use are pencil dots in drawing the lines? How are these dots employed in laying out the vertical and horizontal lines?

CHARTOGRAPHY
IN TEN LESSONS
BY FRANK J. WARNE

LESSON II

THE SCALES OF THE CHART

PUBLISHED BY
FRANK J. WARNE
SOUTHERN BUILDING
WASHINGTON, D. C.

LESSON II

The Scales

Statistical Variables—The Independent Variable—The Dependent Variable—The Horizontal Scale—Determining the Vertical Scale—The Scale Lines—Reading the Scales—Plotting the Statistics—The Use of Gradicules.

The essence of a chart is in the relation which it shows exists between two or more statistical elements. Chartography involves a comparison. Probably the most frequent comparison is that of figures representing the trend or tendency of the same or similar element or factor over a period of time, as in the present instance of our statistics showing the average price of bacon on April 15th of different years.

STATISTICAL VARIABLES

This price is not the same for all the years—it has the capacity of changing or varying with the different periods of time. Thus in relation to each other these two groups of figures are called variables.

THE INDEPENDENT VARIABLE

A comparison being involved, one or the other group must be made use of as the standard by which the other group is measured or interpreted.

The group so used becomes the independent variable. Where the element of time enters into the situation it is nearly always the standard and thus becomes the independent variable.

THE DEPENDENT VARIABLE

The statistical group that is to be measured or interpreted is called the dependent variable. In our present problem the price of bacon being dependent upon the specified periods of time is the dependent variable.

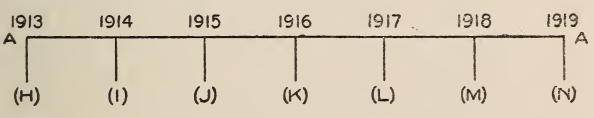
The relation between or the tendency of the units or elements of the dependent variable is measured by scales. One of these is the horizontal scale and the other the vertical scale. Generally the independent variable takes the horizontal scale. This fact is important, as a great deal of confusion results from a violation of this simple principle of chartography.

"It should be a strict rule for all kinds of curve plotting," says Brinton in his *Graphic Methods for Presenting Facts*, "that the horizontal scale must be used for the independent variable and the vertical scale for the dependent variable. When the curves are plotted by this rule the reader can instantly select a set of conditions from the horizontal scale and read the information from the vertical scale. If there were no

rule relating to the arrangement of scales for the independent and dependent variables, the reader would never be able to tell whether he should approach a chart from the vertical scale and read the information for the horizontal scale, or the reverse. If charts are always plotted with the independent variable as the horizontal scale, there need be no question in the reader's mind as to how he should interpret the chart."

THE HORIZONTAL SCALE

Following out this principle of chartography we substitute on the horizontal line A–A of the framework on page 7 (Lesson I), in place of the letters H, I, J, K, L, M, and N, the figures representing the years in our statistical table. This gives the following horizontal scale line:



DETERMINING THE VERTICAL SCALE

With the years representing the horizonta scale, the average price of bacon figures—the dependent variable—must necessarily be measured by the vertical scale. The units of this

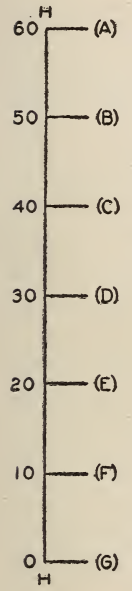
scale are determined arbitrarily by figures that must have a spread sufficient to include the lowest as well as the highest price of bacon that is to be recorded according to the statistical table. The lowest price is 26.4 cents in the year 1915 and the highest is 57.2 cents for the year 1919.

It has already been stated that the lower or base horizontal line is zero and should be indicated by a cipher. This also means, inasmuch as the vertical lines rest upon the base line, that the beginning or start of the vertical lines must be at zero. The framework above the base or zero line G–G on page 7 (Lesson I) provides six squares within which the highest number—57.2—of our statistical table has to be recorded. With these facts to consider it is a simple mathematical computation which shows that the smallest unit that can be made for the vertical scale is that of 10 for each square. Placing this unit from 0 to 60 on the vertical scale line H–H of the framework shown on page 7 (Lesson I) instead of the letters G, F, E, D, C, B, and A, gives the vertical scale on opposite page.

THE SCALE LINES

We have completed both the horizontal and vertical scales as determined by the figures of our statistical table. Substituting these scales on

the frame-work of our chart in place of the letters designating the lines gives the results shown on the next page.

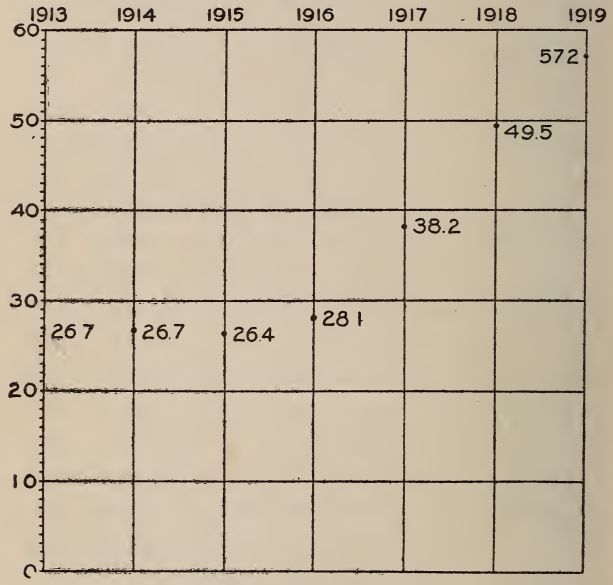


These scale lines—the horizontal and vertical—are very important features of a chart; in fact, without them a chart is unintelligible. They must be adapted to the arbitrary limitations of space, and this adaptation is readily brought about by increasing or decreasing the space allotted to each unit of each scale to correspond to the requirements of the particular statistical problem. The vertical scale unit itself can also be increased or decreased as the particular problem requires. This scale measures, by equal distance along all the vertical lines, the units of the variables that are being charted—it represents by space on the lines of the chart the equivalent of an agreed upon element of the statistics as determined by the units selected.

READING THE SCALES

The horizontal scale should read from left to right with the earliest year to be recorded appearing first and the remaining years following consecutively in point of time.

The vertical scale beginning at zero should read upward from the bottom or base line to the top or horizontal scale line.



This arrangement "faces" the chart to the left. A chart that faces to the right, faces in the wrong direction, or, putting it another way, a

chart that does not face to the left does not face in the "right" direction.

PLOTTING THE STATISTICS

We are now prepared to begin the plotting of the statistics. With the vertical and horizontal lines drawn the proper distance apart and with the figures of the years and vertical scale units correctly indicated by lead pencil marks, the student next begins to plot on the respective vertical lines, by means of pencil dots, the exact positions of the figures of the statistical table as determined by the vertical scale.

This scale applies similarly to measurements on all the other vertical lines as much as it does on the vertical scale line itself. That is, any unit of the vertical scale line, say 30 of our present scale, has exactly the same relative position on all the vertical lines as it has on the vertical scale line.

The first figure of our statistical table that is to be located on the chart is 26.7, representing in cents the average price of a pound of bacon on April 15, 1913. The first vertical line, which is our vertical scale line, also represents that year, as indicated by the figures 1913 at the top of the line. Starting at the base of this line at 0 we proceed upward to 10, to 20, and somewhere be-

tween this unit designation and the next one, 30, must be the proper location for the figures 26.7.

THE USE OF GRADICULES

It is easy to locate where 25 should be—midway between 20 and 30—even without the aid of the slight projections or gradicules which have been inserted on the left of the vertical scale line in the chart on page 18 for the purpose of aiding the beginner. Each of these gradicules represents one-tenth of the vertical scale unit, or 1, and there are ten gradicules between each unit of 10. They perform a function similar to the subdivisions of the inch unit on the ordinary ruler—they enable the student to locate with facility on the framework any figure of the statistical table that falls within the round numbers of the vertical scale units.

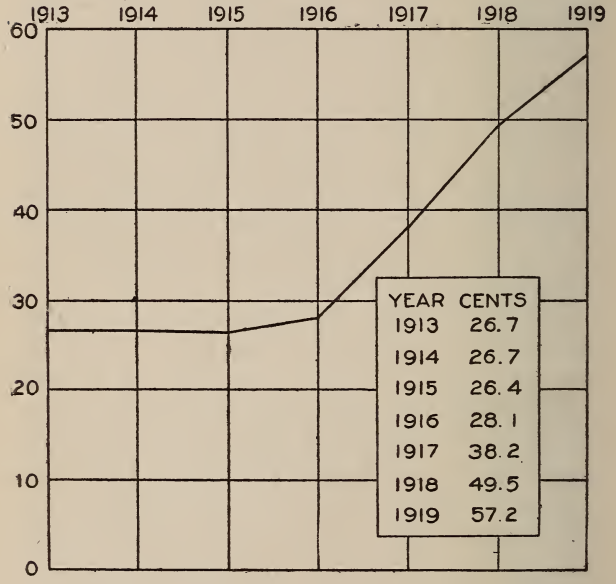
With the assistance of these gradicules it is a simple matter to determine the correct location on the vertical scale line of the figures 26.7. This is indicated by means of a pencil dot. The same procedure is followed in locating on their respective vertical lines, as indicated by the vertical scale, the remaining figures for each of the other six years of the horizontal scale.

The locating of each number on each vertical line should be done by starting at the base or

zero line and counting upward, and not by starting from the position of the preceding pencil dot. One reason for this is to prevent the possibility of error in the location of the numbers in case a mistake happens to be made in placing the first one on the vertical scale line. Besides, it is important that the beginner should have impressed upon his mind at the outset that all positions of numbers charted by means of a curve are determined in relation to the base or zero line. This is clearly indicated on page 18. On this drawing the numbers represented by the pencil dots, and which are those of our statistical table, are placed opposite their respective dots to emphasize their location.

This presentation has prepared the student for the actual drawing of the curve. This he does by starting his pencil at the dot on the vertical scale line representing the number 26.7 for the year 1913, and by means of a straight line marks the space between this dot and the dot representing 26.7 on the second vertical line, which latter, according to the horizontal scale, represents the year 1914. It so happens that the average price of bacon on April 15, 1914, is identical with the price on April 15, 1913, according to our statistical table. This gives a straight line connecting vertical lines 1913 and

1914 at the point 26.7. The dot on the vertical line representing the year 1915 is at 26.4, this figure being the average price of bacon on April 15 of that year. The student connects the dot



representing 26.7 for the year 1914 with the dot at 26.4 for 1915. Continuing this process for the remaining dots gives the curve shown above.

In this drawing the lead pencil dots have been erased, as have also the gradicules along the vertical scale line shown in the chart on page 18, these dots and gradicules being of no further use. The figures representing the price of bacon for the different years have also been removed from their positions opposite the dots and have been placed in statistical table form, with the years in the first and the prices of bacon in the second columns.

QUESTIONS FOR SELF-EXAMINATION

1. What is the essence of a chart?

2. What are variables? What is an independent variable? A dependent variable?

3. What are scales? Describe the horizontal scale. The vertical scale.

4. What is the relation between the variables and the scales?

5. What scale does the independent variable take? The dependent variable?

6. How is the vertical scale determined?

7. What is the base line? What service does it perform? What is the zero line? What is the relation between the lower horizontal line and the zero line? Between the lower horizontal line and the base line?

8. What is a square? How is it formed? What is its function in chartography?

9. What is the vertical scale unit? How is it determined?

10. What is a vertical scale line? A horizontal scale line? What relation to these are the vertical and horizontal scale units?

11. How should the horizontal scale be read? The vertical scale? In what direction should a curve chart face?

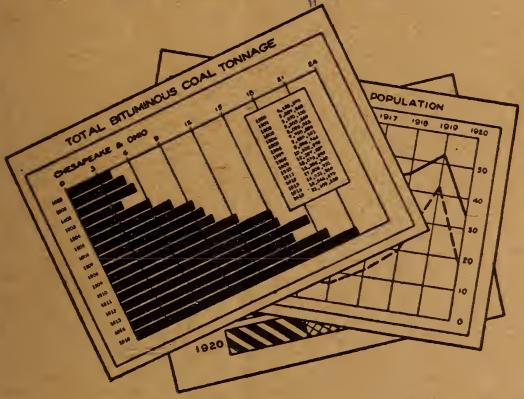
12. What is meant by plotting the statistics? How is it done?

13. What is the relation of the vertical scale units to vertical lines other than the vertical scale line?

14. What are gradicules? Of what use are they in plotting the statistics? Where are they located? Of what use are pencil dots in plotting the statistics?

15. How are the positions of the figures of the statistical table on the framework determined? What service does the zero line perform in this determination?

CHARTOGRAPHY
IN TEN LESSONS
BY FRANK J. WARNE



LESSON III

THE CURVE CHART

PUBLISHED BY
FRANK J. WARNE
SOUTHERN BUILDING
WASHINGTON, D. C.

LESSON III

The Curve Chart

Making the Curve Heavier—The Horizontal Scale Unit—Squares Should be Equal—Effects of Different Scale Units—Dropping the Zero Line—Indicating the Absence of the Zero Line—Divisors for the Vertical Scale.

In drawing the curve remember to make it heavier than any other line. The purpose of this is to have it stand out prominently and so catch and hold the eye of the reader. The curve should be the most conspicuous of any line on the chart for the reason that it embodies or symbolizes the most important facts that are presented—it is the why and the wherefore of the chart being called into existence. Conversely, the framework lines making up the background of the chart, that is, the horizontal and vertical lines, should be drawn with a lighter touch of the pencil to paper.

The curve is a continuous, unbroken line, and has its origin at the point along the vertical scale line that is determined for the time or other designation of that line by the statistics and the vertical scale. It moves across the page from point to point on the vertical lines and in the

direction from left to right as the respective numbers of the statistical table determine. The curve terminates on the last vertical line at the point the statistics require. It takes the shortest distance between two points and generally should approach each slantingly.

THE HORIZONTAL SCALE UNIT

In a curve chart the unit of the horizontal scale element—in our present case this is a calendar year—marks a point as distinct from space between points. Each vertical line projects or extends its horizontal scale unit downward all along the entire distance of that line even to the base or zero line. The curve cannot and does not affect it—the curve does not move any horizontal scale unit a hair's breadth from its place on a particular vertical line. Or, rather, the horizontal scale unit does not follow the curve from its point of contact with it on one vertical line to the point of contact with another horizontal scale unit on another vertical line. For instance, the year 1913 ends with the vertical line so designated and does not cover the space between vertical lines 1913 and 1914. Quite commonly in curve charts this distinction is overlooked, particularly by beginners, and the horizontal scale element is sometimes made to

represent space on the horizontal scale line and between the vertical lines. This is a mistake.

SQUARES SHOULD BE EQUAL

In a curve chart it is desirable to have the curve move from point to point in squares or areas of equal spacing in all directions, whether these be large or small. This means that both the horizontal and vertical scales should be determined upon a basis that will permit equal spacing between the units of each scale, that is, between the horizontal lines of one scale and the vertical lines of the other. This allows the curve to move up or down and from left to right an equal distance for each unit of measurement of both scales.

Many curve charts are being made in which this rule is violated. It must be added, however, that the observance of this principle is not always possible owing to the arbitrary limitations of space and to the necessities of the scales. The problem for the chartographer is to secure as accurate an observance of this rule as his difficulties will permit. He should constantly keep in mind the important fact that the horizontal and vertical lines are made use of to measure the quantity or volume or other specified quality of the statistical element that is charted, and that these rules of measurement should be as fair as possible.

It is recommended that the beginner at first draw his frame work or scaffolding lines, both horizontal and vertical, exactly one inch apart, thus giving square inches within which the curve moves. Each scale will then have its units of measurement one inch distant from each other. Later on the student can practice with lessening or lengthening this distance, keeping in mind not to move the scale units to points less than one-half inch or further apart than one and one-half inches. He should not permit the units of either scale to be separated by any greater distance than the units of the other scale.

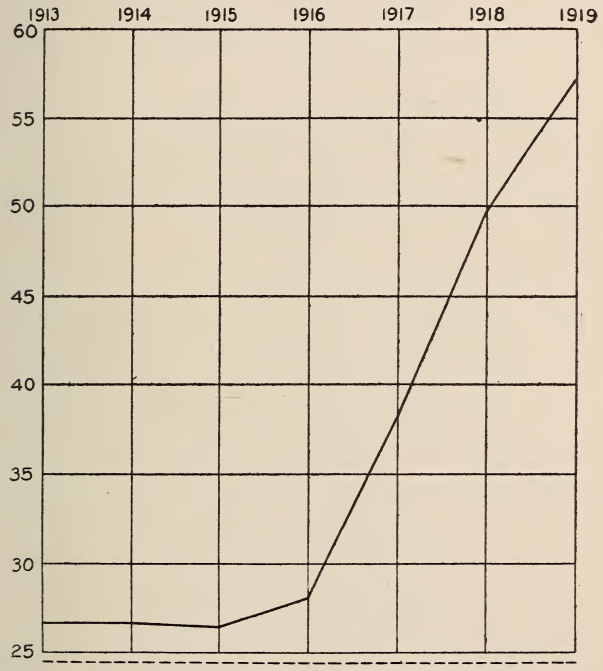
EFFECTS OF DIFFERENT SCALE UNITS

The student should also practice changing the unit of the vertical scale within the inch square, increasing or decreasing it to other selected units, in order to observe carefully the effects these different units have upon the movement of the curve. In the drawing on page 22 the unit is 10. Let us substitute for it the unit 5, as in the drawing on the opposite page. A study of these two drawings will disclose a number of important differences.

Probably the most important of these is the fact that a vertical scale unit one-half as large, other factors remaining the same, doubles the space within which the curve moves. Conversely,

doubling the scale unit decreases by one-half the distance the curve moves.

This space in the drawing on page 22 requires



vertically a fraction more than three of the squares—the spread in the difference between the lowest and highest numbers of the statistical

table is 30.5 and with 10 as the unit this leaves .5 more than three times 10. In the drawing on the preceding page the vertical scale unit 5 requires a fraction of .5 more than six times 5 to accommodate the curve, or seven vertical squares at the very least. As the drawing on page 22 provides only six squares, another one has to be added to the framework, as is done on the page preceding. This is accomplished by inserting an additional horizontal line, either above the top or below the bottom horizontal line, and then extending to it all the vertical lines.

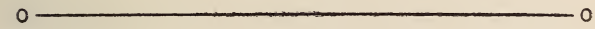
With the new vertical scale unit being 5 and with the highest number to be charted being 57.2 for the year 1919, a square must be provided for each of the units of 5 if the scale is to begin at zero. This demands at least twelve squares for the vertical scale from 0 to 60. But it is physically impossible to accommodate this many squares of the present size within the space limitations.

DROPPING THE ZERO LINE

The next step is to ascertain from the statistical table the lowest number to be recorded. This is 26.4 for 1915. It is clear from this that the space occupied by all the squares below the vertical scale unit 25 will not be needed for recording the movement of any part of the curve, for

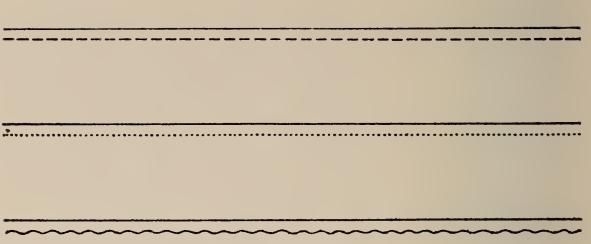
in not a single year of all the seven given in the statistical table does the price of bacon fall below that unit. Consequently, beginning the vertical scale at 25 instead of at 0 permits the elimination from the framework of five squares. The number that remains, which is seven, is sufficient for the requirements.

It has been made clear in preceding Lessons that the bottom horizontal or base line of a curve chart represents zero of the vertical scale and is indicated by a cipher as follows:



INDICATING THE ABSENCE OF THE ZERO LINE

Such a line, of course, cannot possibly be used as the base line with the unit of our vertical scale starting at 25, so the zero designation is omitted. Attention should always be called to this omission on the chart itself and this can be done by inserting directly below the base line, with its proper unit designation, a faint line of dashes or one of dots, or a wavy or slightly undulating line, as indicated on the next page. Rulers provided with these undulations can be purchased.



The student should keep in mind as a general principle the fact that the vertical scale begins on the base line at 0, although he will frequently find that this is physically impossible because of the nature of his statistical problem. This prevails more often among large numbers than with percentages. Usually the lowest number to be charted starts at a point so high above 0 that the space required to show the latter on the chart is out of all proportion to that necessary to indicate the movement of the curve. Again, frequently in such cases the vertical scale unit determined by including zero becomes so large that fluctuations in the movement of the curve reflecting the trend of the statistics (which fluctuations would be made clear by the use of a smaller unit) are smoothed out or flattened so that that which should be a curve approaches nearer to a straight line. Thus it is not always possible to plot a curve chart so that the zero of

the vertical scale will be shown and at the same time clearly present the trend of the statistics, which latter is the primary object of the curve.

In beginning to read a curve chart, among the first things to be observed is whether the vertical scale starts at zero and if it does not to make proper allowance for this fact in the interpretation of the movement of the curve. Unless this is kept in mind an erroneous idea or impression of the extent of the movement will result. A chart that does not present the zero line and fails to call attention to the omission in the ways indicated, or neglects similar precautions, is constructed in error. Such a chart is very likely to be misleading no matter how excellent or perfect its other features may be.

DIVISORS FOR THE VERTICAL SCALE

The selection of the vertical scale unit is thus not without its difficulties. These the student will learn to overcome as his experience with varying statistical problems increases. He will learn, among other things, that particular numerical divisors are more advantageous as units than some of the others.

The divisor 3, for instance, is an awkward and inconvenient scale unit, not only for computing on the vertical lines the measurements of the

statistical element but also for calculating by the interpreter of the chart. The divisor 2 is much better, and 5 and 10 are nearly always ideal. Such units as 3, 4, 6, 7, 8, and 9 are not as good as 2, 5, 10, 20 and so on, the latter group being more easily divisible into the spaces along the vertical lines as well as into the numbers of the statistical table.

Whatever scale unit is selected it must permit the inclusion within the arbitrary limitations of the framework of the smallest as well as the largest number that is to be charted. The unit must be such as to permit of a spread between the lowest and highest numbers charted sufficient to bring out clearly in the curve the points or tendency to show which the particular chart has been designed; at the same time it must not be too small as to result in exaggeration. It is as serious an offense to exaggerate with curves as it is with words. Accuracy in chart expression is as important as is the use of words in expressing thought, and the various uses or functions of the vertical scale unit have much to do with accuracy in curve charts.

On a finished chart the student will not find any dots and similar marks used as guides in erecting the scaffolding of the framework, which means that all such marks must be erased from

the completed chart. He will find, however, that all the vertical and horizontal lines make complete right angles at all points of junction; that all such lines are straight lines; that they form accurate squares; that the curve is slightly heavier than the other lines; that the scale unit figures are in their correct positions in relation to their respective lines; and that the horizontal and vertical scale unit figures do not crowd the lines but are separated from them by the correct spacing.

QUESTIONS FOR SELF-EXAMINATION

1. Why is the curve made heavier than other lines?
2. Define a curve. How is it emphasized in comparison with the horizontal and vertical lines?
3. Define the horizontal scale unit. What function does the vertical scale lines perform for this unit? What is the relation of the curve to it?
4. What effect have unequal squares on the movement of the curve? What relation is there between the squares and the scale units?
5. What are some of the effects of changing the vertical scale unit?
6. When is the zero line omitted? How is this omission indicated?
7. Explain the reasons for omitting the zero line.
8. What effect has the omission of the zero line on the reading of the curve?
9. What are numerical divisors? When and how are they used? What ones are better than others?
10. What must the divisors provide for?

CHARTOGRAPHY
IN TEN LESSONS
BY FRANK J. WARNE

LESSON IV

FEATURES OF A COMPLETE CHART

PUBLISHED BY
FRANK J. WARNE
SOUTHERN BUILDING
WASHINGTON, D. C.

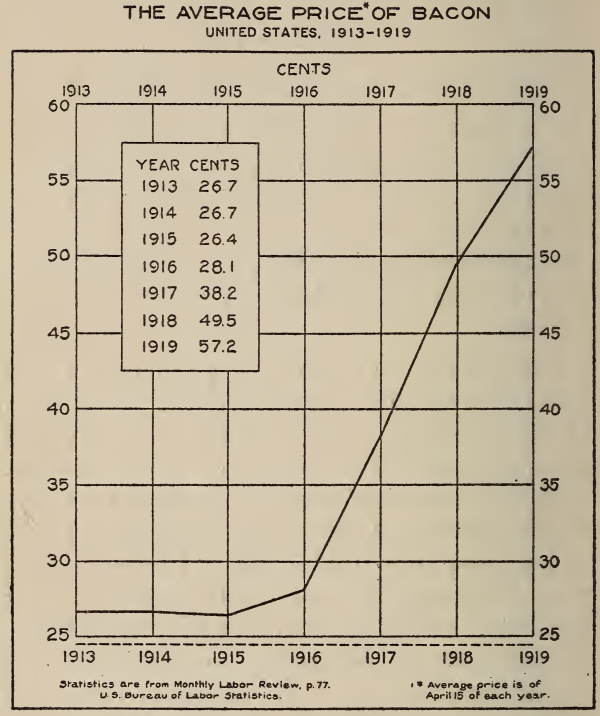
LESSON IV

Features of a Complete Chart

The Statistical Table—Table Should Appear on Chart—The Make-up of the Table—Spacing the Columns—The Form of the Table—Duplicating the Scale Units—The Place for the Horizontal Scale—Word Designation of the Scale—The Title—The Foot-Notes—The Neat Lines.

The drawing on page 38 is a complete curve chart constructed according to the instructions of the preceding Lessons. The student should examine carefully every one of its features.

Particular study should be given by the student to the statistical table. It occupies the position in the lower right hand corner of the drawing on page 22 (Lesson II) but in the accompanying chart it is located in the upper left hand corner. In each case the location of the table is adapted to the requirements of the particular chart and each is correctly placed. It will be found that one or the other of these two positions is usually the place for the table, the lower left hand corner and the upper right hand corner nearly always being required for the free and unobstructed movement of the curve.



This simply means that there is no arbitrary position on the chart for the statistical table but that its location is determined by the result of the plotting of the curve. The only general rule to follow is to place the table of figures in the

particular position on the chart that displays it to the best advantage without at the same time crowding the scale lines or interfering with the curve. Breaking the vertical lines 1914 and 1915 and the horizontal lines 45, 50, and 55, as is done in the accompanying chart, is not objectionable but rather advisable in preference to these lines extending through and breaking up the table.

"Boxing" the two columns of the table with light lines, as in the accompanying chart, adds to the neat appearance of the finished diagram.

TABLE SHOULD APPEAR ON CHART

Virtually every chart is based upon statistical information. Usually this information is in the form of a statistical table or columns of figures. If the chart has been properly constructed and if the figures of the table are correct, the presence of the statistics is not essential to a complete understanding of the chart—its meaning will be clear without the figures. Nevertheless it is highly important in good chart making that the statistics upon which the diagram is based should occupy an important place on the chart.

This reproduction of the figures furnishes proof, if proof is needed, of the correctness of the movement of the curve as shown in the chart and will also be of service to those who may wish to use the

data in other directions or to make different compilations. Unless the statistics from which the chart is made are shown upon it there is no easy way to check up the work of the chartographer.

THE MAKE-UP OF THE TABLE

The internal make-up and arrangement of the statistical table also require some thought from the student. Its construction would appear at first glance to be an easy thing to do and yet the task has its difficulties.

All the numbers of the same statistical element that are to be compared should be placed in the same vertical column one under the other and not too far apart, the digits of the tens and hundreds and so on occupying their proper positions in relation to similar digits of other numbers in the same column. In the case of years, these are arranged vertically and in proper sequence of time one under the other with the earliest year at the top and the latest year at the bottom of the column. Nearly always the years are in the first column to the left in a table of two or more columns. Vertical columns of figures read downward from the top and never upward from the bottom. This is in inverse order, it will be noted, to the reading of the vertical scale units.

Each column has its proper word designation

just above the first number, as years and cents in the table of the chart on page 38. This is the column heading. The space for it is usually very limited and for this reason it should be confined to simple words of the fewest possible letters consistent with clearness as to the meaning of the column of figures. Double meaning of words should be as carefully guarded against as indefiniteness in meaning, each being a serious offense against clearness of expression. When two or more words are necessary in the heading of a column it is usually advisable to make of them two or more lines just above the first number, with each word having a line to itself instead of all the words occupying a single line, which latter nearly always extends the heading too far on either side of the column of figures.

SPACING THE COLUMNS

Where two or more columns of figures are in the same table attention has to be given to the proper spacing between the columns as well as between the numbers themselves and their headings. But in every table the number of columns should be strictly limited to the fewest possible for the purpose in view, the inclusion of any that are not necessary detracting from the emphasis that must be given to the principal

facts and tendencies shown by the statistics. The table must be complete in itself, however, with no vitally important factor missing. To this end more than one comparison should not be attempted in the same table.

The form of the table has to be adjusted not only to the size of the chart but in particular to the space available on the framework for its presentation without interfering with the curve. Interference by the table with the light horizontal and vertical lines is not so important; nor is a correct interpretation or reading of the curve interfered with even when the vertical scale line is broken into by the table at points which the curve does not approach.

THE FORM OF THE TABLE

There are distinct forms best adapted to particular purposes with which the student will become familiar only by practice. He will have to decide at times whether he will include all his data in one table or break them up into two or more tables with a chart to illustrate each. Compactness as well as proximity of the numbers for comparative purposes are advantages which must sometimes be surrendered at the demand of more pressing requirements. If the table is too large confusion to the eye results and difficulty is

encountered in following the significance of the separate columns. Interpretation also is particularly taxing if the tabulation is dealing with a complex mass of figures.

SIMPLICITY THE GUIDING RULE

If the student will keep in mind that simplicity must be the guiding rule he will usually not go far wrong in his decisions. Much, of course, depends upon the data that must be shown but quite often more can be eliminated from the columns than at first seems possible. Foot-notes as explanations of the table often show a way out but these should be kept at the minimum. A title to the table separate from that of the chart is unnecessary.

Sometimes the exigencies of space limitations combine with the requirements of the movement of the curve to prevent the use of the form of statistical table that has been described and which is shown in the chart on page 38. In such cases recourse has to be had to some other form, sometimes to that shown on page 4 (Lesson I) with the years and prices of bacon arranged in horizontal lines instead of vertical columns. At times when this form has to be resorted to it is not possible to place the table within the framework and in such cases a position has to be found for it elsewhere on the chart.

DUPLICATING THE SCALE UNITS

In the chart on page 38 the unit figures of the horizontal scale have been placed on both the top and bottom lines and those of the vertical scale on both the first and last vertical lines. This arrangement has many advantages. While it is not essential to the reading of the curve, at the same time it facilitates the interpretation of its movement in that the reading of the prices of bacon for the first and immediately succeeding years is permitted without requiring the eyes to move upward to observe these horizontal scale units; also, it permits the quick reading of the prices of bacon for 1919 and the immediately preceding years without requiring the eyes to travel across the page to observe these particular vertical scale units. The scale units arranged along all four sides also serve to give a border-like appearance to the framework and introduce a little greater uniformity in place of a tendency towards a lack of balance.

THE PLACE FOR THE HORIZONTAL SCALE

Some chartographers prefer placing the horizontal scale units along the bottom line only. My own preference is that where they are to appear only once on the chart then the place

for them is on the top line. That line will be found to be much more convenient as the horizontal scale line; besides, there are other important uses for the bottom horizontal line, such as serving as the base line and as the zero line.

This preference is influenced also as the result of more than ten years' experience in chart making for practical commercial purposes. During this experience it has been observed that most people in reading a chart start at the top with the title and glance downward. With the units of the horizontal scale on the top line the reader early in the process of interpretation is informed of these important facts which he must know if he is to read the chart intelligently and correctly.

Placing the horizontal scale units on the bottom line meets with the objection that the space beneath this line is usually needed in most curve charts for important explanations and footnotes, such as credit for the source of the statistical information upon which the chart is built, notice of copyright, and so on. With the horizontal scale figures also there that section of the chart is likely to give the appearance of crowding.

Again, with the horizontal scale figures located on the bottom line I have frequently encountered practical difficulties hard to overcome because the first and last of these units interfere with

those of the lowest scale measurement of the vertical lines, both sets of figures being located at nearly the same point of the right angles formed by these vertical and horizontal lines. As opposed to this, it is nearly always possible to extend the upper part of the framework at least one series of squares beyond the highest point to be recorded by the vertical scale and this permits the figures of the horizontal scale units to have a line all to themselves without interfering with and without interference from any of the figures of the vertical scale.

There is no objection, of course, to reproducing the horizontal scale figures on the bottom line whenever there is room for them, and this practice is recommended as being advantageous, especially in charts of unusual depth, as it facilitates a quick reading of the curve movement.

WORD DESIGNATION OF THE SCALE

Further assistance in the interpretation of the chart, and especially in the reading of the curve, is rendered if the primary characteristic of the statistical element represented by the vertical scale is indicated by a word designation just inside the top border line and directly above the center of the horizontal scale line. This is shown in the designation "Cents" in the chart on page

38. Such a designation states concisely to the reader what the vertical scale figures represent—it explains the essence of the curve. Its value and usefulness will be impressed upon the student as he progresses in his studies.

THE TITLE

Another important matter to be considered before our chart is a complete one is the title or heading. Every chart *must* have a title. Without it the chart is almost as incomplete as it would be if the curve itself were omitted. The title is as much a part of the chart as are the scale lines or table of statistics. It is more important than the beginner in chart making is apt to realize.

The title should not contain a single unnecessary word. The space for it is usually limited and too many words detract from the effect in expressing the idea intended. Simple words of one syllable are preferable. This choosing of words in the selection of a title is a splendid exercise in enabling one to secure a better command of the English language and in comprehending more clearly himself the essence of the chart. The title should be so clear in its meaning that misinterpretation is impossible, and so comprehensive in its scope as to cover all the import-

ant data presented by the chart so that the interpreter will not have to look elsewhere for explanation. This is not always possible and in such cases a foot-note explanation at the bottom of the chart is advisable. Indefiniteness in title meaning is a serious offense. Similar statements are equally applicable to any sub-title.

The position of the title is, of course, at the top or head of the chart, as shown on page 38. The best title is one comprising a single line but this is not always easy to accomplish. In the chart referred to it has been found necessary to have two lines in the title, and in such cases the letters of the words in the second line should be slightly smaller than those of the first line. The principal idea in this chart is the tendency in the price of bacon, so its title becomes "The Average Price of Bacon." But as this does not give the information quite complete enough, the reader is told in the second line that the price is for the entire "United States" and for the years "1913 to 1919." The asterisk after the word "price" refers the reader to the foot-notes, where it is stated that the average price given is of April 15 of each year.

THE FOOT-NOTES

The place on the chart for the foot-notes is

just below the base line and outside the framework proper. These serve a useful purpose in presenting descriptive information sometimes necessary to clear up a point that has not been brought out sufficiently in the chart, as indicated in the use of the asterisk in the chart on page 38. In the foot-notes there should always be a statement as to the source of or authority for the statistics upon which the chart is based. This is shown on the chart just referred to by the notation "Statistics are from Monthly Labor Review, p. 77, U. S. Bureau of Labor Statistics." The foot-notes also supply a convenient place for the legal statement required in case the chart is copyrighted.

THE NEAT LINES

With the drawing of the border or "neat" lines, one on each side of the framework and usually about one-half an inch from the horizontal and vertical scale lines, the chart is completed. These neat lines give a sort of frame to the chart, as shown on page 38.

In a good curve chart the principal conclusions to be drawn from the statistical table are made plain, all doubt as to the tendency or course of the phenomena represented by the numbers is removed, and all possible errors have been elimi-

nated. This ability to analyze the significance of a table of statistics, to interpret the results correctly and clearly, and to indicate the conclusions lucidly and succinctly is one of the characteristics of chartography. The results disclosed by a curve based upon a statistical table quite often reveal at a glance important facts that could not have been known except from considerable study of the figures by an expert. Usually an accompanying explanation or analysis is unnecessary. If so the chart has failed of its primary purpose.

The task of checking-up is not optional with the student; it is compulsory—he not only should but he must go over carefully each chart from top to bottom.

If it is a curve chart, do all the horizontal scale units center on the end of the vertical lines?

Are the respective vertical scale units on the right in the curve chart directly opposite and at the end of the same horizontal line as those on the left?

If the curve chart contains a zero or 100 per cent line, has it been made wider or heavier than the other horizontal lines? If the zero line is not shown, does the bottom or base line clearly indicate that the vertical scale does not begin with zero?

If it will aid in the easy reading of the curve see that the horizontal scale figures are duplicated at the base line.

In most curve charts it is best to have the vertical scale figures on the right as well as on the left vertical scale line. If only one set of scale figures are used, however, these should be alongside the first or left vertical line.

Do not make use of the first and last vertical lines of a curve chart as the neat lines of the frame. They should be reserved strictly for the vertical scale units and should be no heavier or wider than the interior vertical lines.

Do not forget that it is the independent variable that takes the horizontal scale, especially in curve charts involving periods of time.

Follow each curve from its beginning on the left to its termination on the right to see that it is continuously correct—that there is no "break" in it. See to it also that the curve is a slightly heavier line than the vertical and horizontal lines.

QUESTIONS FOR SELF-EXAMINATION

1. Describe in general terms the most important characteristics of a curve chart.

2. What is the statistical table? What is its relation to the curve?

3. What is the position of the table on the chart? What are its general features? What is meant by "boxing?"

4. What is the internal make-up of a table? What is a column heading? What is meant by spacing?

5. What is the guiding rule in table construction?

6. What features of the chart affect the form of the table and its position on the framework?

7. What is meant by duplicating the scale units? How is this done? What are the advantages?

8. What is the position for the horizontal scale? Give reasons supporting your statement.

9. What is the function of the word designation of the vertical scale?

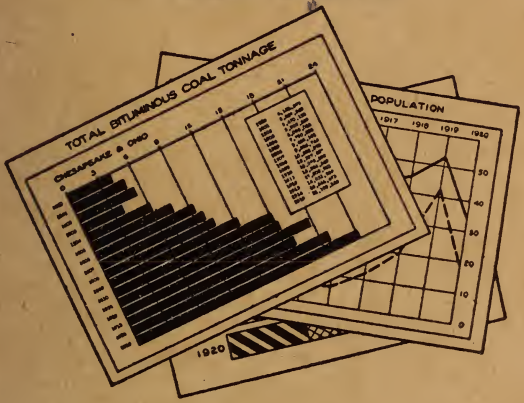
10. What is the title? What is its location? Describe the principles underlying the selection of words for the title.

11. What is an asterisk? What are its uses in chartography?

12. What service do foot-notes perform? Where are they located on the chart? What do they usually comprise?

13. What are neat lines? What is their position on a chart?

CHARTOGRAPHY
IN TEN LESSONS
BY FRANK J. WARNE



LESSON V

THE BAR CHART

PUBLISHED BY
FRANK J. WARNE
SOUTHERN BUILDING
WASHINGTON, D. C.

LESSON V

The Bar Chart

Making Bars from a Curve—Making a Curve from Bars—Advantages of the Horizontal Bar —Reversing the Scales—Width of the Bar— Separation of the Bars—Location of the Table —The Bar and the Curve.

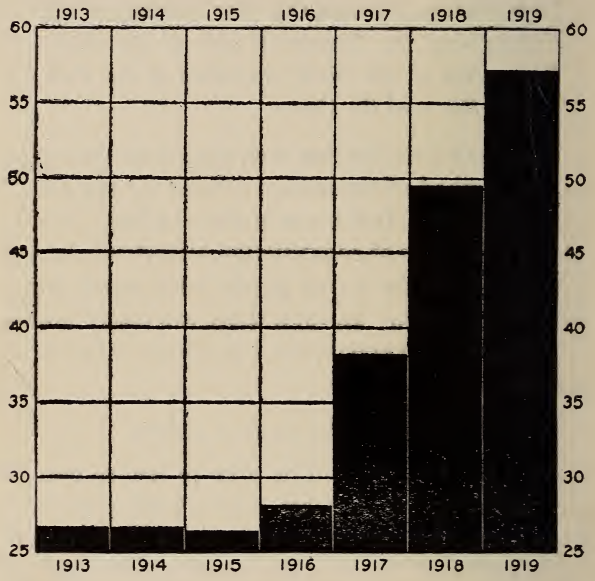
Emphasis thus far has been placed on the curve as the method of expression offered by the art of chartography. But there is also the bar. Many of the principles of construction already explained in describing the curve apply with equal force to the bar chart. In fact, there are many points of similarity between these two different kinds of charts.

MAKING BARS FROM A CURVE

This the student will be able to realize clearly by taking a curve chart and drawing vertical bars from its base line to the points of the curve. This has been done in the chart on page 54. It is merely the result of taking the curve chart on page 38 (Lesson IV) and with as few changes as possible transforming it into a bar chart.

In order to secure a bar for each of the seven years it is necessary to add another vertical line

to the right of the one for the year 1919 and extend to it the top and bottom horizontal lines. The horizontal scale unit for each year is moved to the right from its former position at the top



of a vertical line so as to occupy space between the vertical lines and to be above the top of the bar. No change is made either in the unit of measurement of the vertical scale or in its location.

MAKING A CURVE FROM BARS

This procedure enables the many points of similarity between the curve and the bar chart to be quickly recognized. This similarity will all the more be indelibly impressed upon the mind of the student if he will take the vertical bar chart on page 54 and draw a continuous curve from left to right touching the tops of all the bars. Then if he will cut out a piece of blank paper so that its upper edge conforms roughly to the curve he has drawn he will find, by placing this on the bars, that the latter are hidden from view and that the curve remaining in sight expresses just as clearly the tendency shown by the bars. In other words, his cut piece of blank paper has simply restored the original curve chart on page 38 (Lesson IV).

This procedure also emphasizes strikingly the essential difference between these two kinds of charts. This difference lies primarily in the fact that the horizontal scale of a curve registers points *on* lines while the horizontal scale of a vertical bar chart registers space *between* points on lines.

But in changing the curve to the bar we have not secured a good bar chart. In the first place the bars are entirely too wide to represent such small amounts as cents. In the second place the bars take up entirely too much space—the same

ends can be accomplished by the use of a narrower bar. In the third place the result is a vertical bar, that is, a bar standing upright on its end. A horizontal bar, that is one lying on its side and extending from left to right, is preferable.

ADVANTAGES OF THE HORIZONTAL BAR

This preference is based on an experience of years in meeting the every-day problems of chartography. It convinces the writer of the greater utility of the horizontal bar. Quite probably there are occasions when it is advisable to have recourse to the vertical bar, but at the same time where there is a choice between the two the horizontal bar will be found to be more advantageous. It gives greater opportunity for the display of letters and figures where the limitations of space or other considerations require that these be placed on the bars themselves. In such instances, in order easily to read the words or figures on vertical bars the chart usually has to be turned half way round to the right, whereas if the bars are horizontal the figures and letters read in the natural direction. In brief, with the vertical bar the chartographer will encounter more difficulties than with the horizontal bar in the placing of his table, figures, and letters. The ability to select advisedly in those cases where it

might be advantageous to employ the vertical bar will come to the student with practice and experience. It is recommended that in the meantime he confine himself to the practice of the horizontal bar.

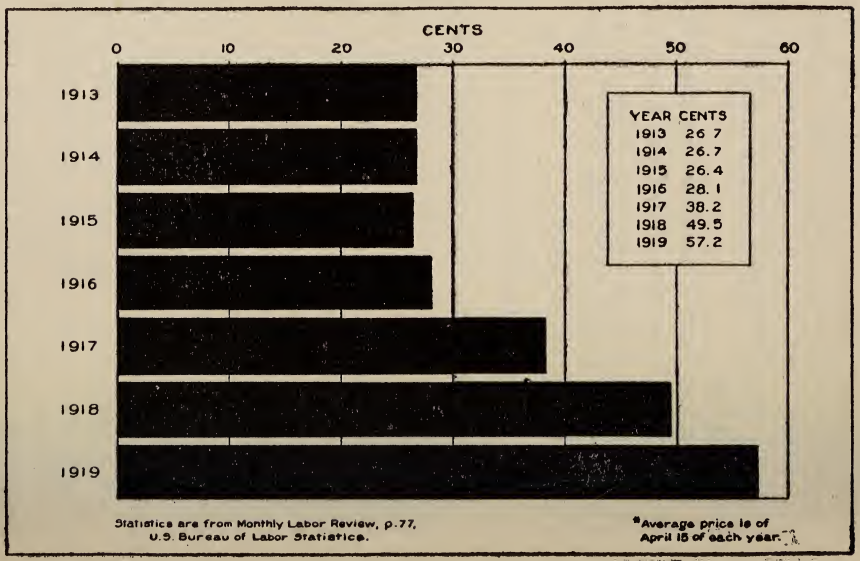
Such a bar chart is presented on the following page. It will be observed, from a comparison of its statistical table with that of the curve chart on page 38 (Lesson IV), that it is constructed from the same set of figures.

REVERSING THE SCALES

The horizontal bar has necessitated a reversal in the location of the scales in comparison with those of the curve. Instead of the independent variable—the years—occupying the horizontal scale position it takes that of the vertical scale, and the dependent variable—the prices of bacon—becomes in turn the horizontal scale. This permits of the measurement of the movement of the bars from left to right and not from the bottom up, as with the vertical bar. Otherwise we could not secure the advantages of the horizontal bar.

In a horizontal bar chart the figures of the vertical scale, quite frequently comprising periods of time, are located directly to the left of the beginning of the bars, the figures for each year being centered adjacent to their respective bar.

THE AVERAGE PRICE* OF BACON
UNITED STATES, 1913 - 1919



The last digit of the number should not be permitted to crowd the end of the bar too closely.

WIDTH OF THE BAR

It will be noted that the bars are narrower in the chart on page 58 than in the one on page 54. This feature of the bar is important. Just how narrow or how wide or deep the bar should be will depend upon a number of factors, such as the nature of the particular statistical problem, the arbitrary limitations of space, and so on. No definite rule can be given except that all the bars of a chart must be of uniform width, they should be sufficiently wide to be easily seen, and they should convey an impression of the volume or quantity represented. For instance, a bar representing billions should be wider than one representing millions; the latter wider than one representing hundreds of thousands; and the latter of greater width than one representing thousands, and so on. Wide bars are preferable to too narrow ones.

In beginning to draw the bars the student should indicate on the sheet by light lead pencil lines instead of dots the width and length of each bar, the former being arbitrarily determined by the number of bars that is to go in the available space and the latter by the quantity or volume each bar represents as determined by the statis-

tics and the scale unit. It is first advisable to determine from the statistics and the horizontal scale unit the length of the shortest and the longest bar. All the other bars fall within the limits these two set. Begin plotting the chart with the bar for the earliest year at the top and just beneath the horizontal scale line, outlining the bars downward as the years determine. These skeleton bars should then be filled in black by rotating the pencil point within the outlines.

SEPARATION OF THE BARS

Between each bar representing the statistical element of the vertical scale there should be a separation sufficient to distinguish it from the preceding and following bar. In the chart on page 58 this has been done by leaving in the original drawing a space equal to one-tenth of an inch. Usually this is too much spacing. Besides, it requires a greater amount of painstaking labor than should ordinarily be given to a bar chart. How this labor can be eliminated the student will be informed in a succeeding Lesson.

The bar chart on page 58 shows the vertical lines extending from the points of the scale units on the top horizontal line to the base horizontal line except where the bars and the statistical table intervene. These extend downward

the units of measurement of the horizontal scale to each of the seven bars at the various points of contact of the vertical lines with the bars. Ordinarily these vertical lines should not be extended between the bars but to the first bar only that interferes with their further extension. These lines are permitted to be seen on this chart merely to inform the student as to the purpose of the vertical lines in a bar chart. All sections of vertical lines that have been drawn within the bars should be pencilled out of observation as the body of the bar is pencilled in.

LOCATION OF THE TABLE

The location of the statistical table in the upper right hand corner is that which will usually be found best adapted for this use. This is true because this position, as a general thing, is opposite the shortest bars and thus has the largest area of unoccupied space. The lower right hand corner is frequently taken up with the extension of the longest bars representing the largest numbers to be charted, and the upper and lower left hand corners always contain the beginning of the bars.

In cases where the extensions of the bars from the earliest to the latest years show a decrease instead of an increase, the statistical table should be located in the lower right hand corner. The

table should be "boxed," that is, enclosed in a light frame composed of two vertical and two horizontal lines connecting at their ends and forming right angles.

Separating the numbers from their table and placing them on the individual bars adjacent to the figures of the years will sometimes be found advantageous.

THE BAR AND THE CURVE

As between the bar and the curve chart the latter will be found to be much more useful as well as more adaptable to a larger number of statistical tables or problems. It is true that in many instances either may be employed with equally successful results. The bar chart, however, is the most common at the present time not only because it is the simplest to construct but also to interpret. Its advantage lies in its simplicity—the amount or quantity or statistical element is simply represented by the length of the bar. This gives only one dimension to be read and in consequence there is little ground for misinterpretation. As a general statement the bar method should be used where the numbers represent large volumes or quantities.

At the same time there are special problems in chartography which the curve chart alone will

solve to the best advantage. Just what are the particular characteristics of these problems the student will learn by experience. The kind of chart that will best bring out the true significance of a statistical table is the one to select. It can be said generally that with statistical tables having numbers representing very large amounts, such as billions and millions, the bar chart is preferable. Conversely, where the numbers represent small amounts, such as hundreds and tens, the curve chart is usually the best. One reason for this is that the bar conveys the idea of volume to a greater degree than does the curve.

The difference between these two kinds of charts is strikingly presented by Brinton in his *Graphic Methods for Presenting Facts*. He first compares bars representing years or other intervals of time with progress photographs. Though the bars and progress photographs are valuable, he says, they give information only in spots. Then he says:

"A moving-picture machine shows pictures so rapidly that the pictures blend into a continuous narrative in the eye and the brain of the observer. What the moving-picture is to separate progress photographs, the curve is to detached bars representing time. In just so much as the moving-picture is superior to separate pictures shown by lantern slides, in just that much is a curve superior

to a series of horizontal or vertical bars for the same data. Unless a person knows thoroughly how to read and how to plot curves he cannot hope to understand the graphic presentation of facts."

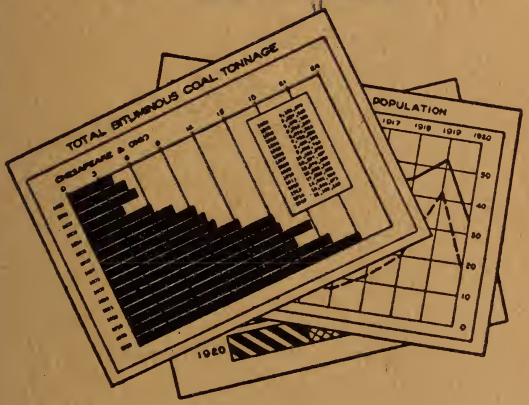
Brinton also says: "A curve permits of finer interpretation than any other known method of presenting figures for analysis—it gives information which many persons might not fully grasp if only a column of figures were used." And again the same author says: "One of the chief advantages of the curve method of presenting information is that a curve forces one to think."

It will be found that plotting the curve is simpler than plotting the bar. It also consumes less time. Many chartographers prefer the curve to the bar method of presenting statistics because it not only brings out the fluctuations from year to year more clearly to the eye but also enables the reader to grasp more readily the tendency shown. The curve is gradually supplanting the bar in popular usage because of its greater clearness, and this tendency is likely to grow stronger as its advantages over the bar are more generally recognized.

QUESTION FOR SELF-EXAMINATION

1. Describe the similarities and differences of the curve and bar chart.

CHARTOGRAPHY
IN TEN LESSONS
BY FRANK J. WARNE



LESSON VI

THE TOOLS OF THE CHARTOGRAPHER

PUBLISHED BY
FRANK J. WARNE
SOUTHERN BUILDING
WASHINGTON, D. C.

LESSON VI

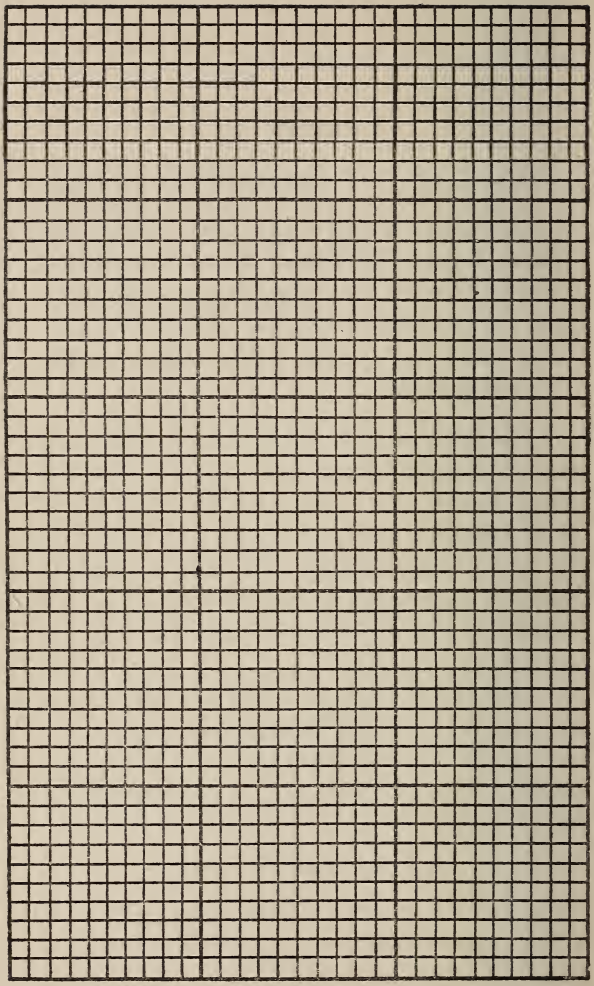
The Tools of the Chartographer

Cross Section Paper—The Lead Pencil—The Kind of Ink—The Ruling Pen—Correct Position for Holding Pen—Pen Points—The Drawing Board—The T-Square—The Triangle—The Engineer's Scale—The Dividers—The Essential Tools.

If the beginner has profited to the full extent from a careful and painstaking study of the preceding Lessons he is now qualified to drop the blank sheet of ordinary paper, the lead pencil, and the common ruler and take up the real materials and tools of the chartographer. The proper use of these materials and tools will measurably facilitate and make less difficult the mechanical work of chart making and will also result in much better workmanship. It permits of the chart becoming permanently valuable as well as of its reproduction in any number desired.

CROSS SECTION PAPER

The most important of the essential materials is the cross section or coordinate paper. A sample illustration is shown on the following



page. This section paper comprises minute squares formed by horizontal and vertical lines. On the most commonly used section paper each minute square measures one-tenth of an inch. One hundred of these squares make up a larger square of one inch, the border lines forming the square inch being slightly heavier than the other horizontal and vertical lines. Section paper can also be secured that has other rulings, such as eight minute squares each way or sixty-four to the square inch, and six each way or thirty-six to the square inch.

Cross section paper thus presents a system of squares whose lines permit the easy measurement or determination, by means of space or distance on the sheet, of the quantity or volume or whatever element it is the statistical table represents. By combining squares, space units of measurement as extended in both directions as the particular problem requires are readily determined.

A sufficient quantity of section paper for most charting purposes can be obtained at almost any first-class stationery store. If a large number of different charts is to be made the varying scales will likely require different subdivisions of the square inch and as it requires too much detail labor for the chartographer himself to draw these subdivisions, it is advisable for quantity produc-

tion to keep on hand a supply of coordinate sheets with the different rulings. Even then the chartographer will not always have paper with the ruled spaces exactly corresponding to his requirement, and in such cases he will have to do the ruling himself.

In sheet sizes the section paper is usually 17 by 22 inches. These sheets can be cut to meet almost any ordinary requirement; or two or more can be pasted together along the edges to meet the demand for a larger surface than that commonly required. Built-up sheets of paper can also be formed from remnants by pasting. If a larger section-ruled surface than 17 by 22 is frequently required it will be advantageous to purchase the coordinate paper in rolls, in which form it is also prepared commercially.

The section paper used should be of the best quality. There are cheap grades on the market but these do not take the ink satisfactorily and have other defects, so that in the long run it pays to purchase the better grade at little higher prices. Of course, a higher price does not necessarily mean a better grade, but it usually does.

The section paper best adapted to ordinary chart work has the horizontal and vertical lines ruled in blue ink. On some section paper these lines are in green or purple but these colors are

not so desirable, as they are likely to reproduce lines on the photographed chart that should not be shown. Paper with a soft surface should also be avoided as it will not take the ink properly, and from now on we are to make all our charts with pen and ink instead of pencil.

THE LEAD PENCIL

This does not mean that the student will have no more use for the lead pencil. In fact, he will continue to have constant need of it. The lead should be neither too soft nor too hard—it should not be so soft as to crumble, or so brittle as to snap in two or so hard as to penetrate or puncture the drawing sheet. The best grade for general use is HB.

Virtually all points of measurement, such as the distances from unit to unit of the scales and those of the curve and each bar, should first be indicated on the section sheet by light lead pencil marks or dots. This use of the dots will facilitate the drawing of the lines, curve, and bars in ink. The entire curve and an outline of each bar might with advantage first be drawn in light lead pencil, the ink being later superimposed after the student has satisfied himself that his pencil markings correctly represent the data. The dots and other lead pencil markings can be erased after the ink

has dried. It is much easier to correct a mistake made in lead pencil than one made in ink. The curve itself is made finally with the draftsman's ruling pen. The neat lines of the frame are drawn in ink after the framework of the chart has been entirely completed.

THE KIND OF INK

The best black ink for charting purposes is Higgins' American India. In purchasing ask the dealer for waterproof quality. This, when it dries, is insoluble and will not smear or spread in case the sheet is brought in contact with water, as is often the case when the chart is to be reproduced by the blue-printing process. Another favorable quality of this ink is exhibited in the process of drying areas on charts, such as bars, as it dries with a flat or "dead" surface. Such a surface is highly desirable in case the chart is to be reproduced by such photographic processes as zinc-etching, photo-lithography, and so on. "Chin-chin" ink, also an India ink and noted for its opacity, can be used to special advantage in cases where the chart is to be reproduced by the blue-printing process. While special mention is made of these two inks, there are also other India inks on the market equally as good for ordinary charting purposes. With the smaller bottles is

usually supplied a beveled quill inserted in the cork which is used in filling the ruling pen.

THE RULING PEN

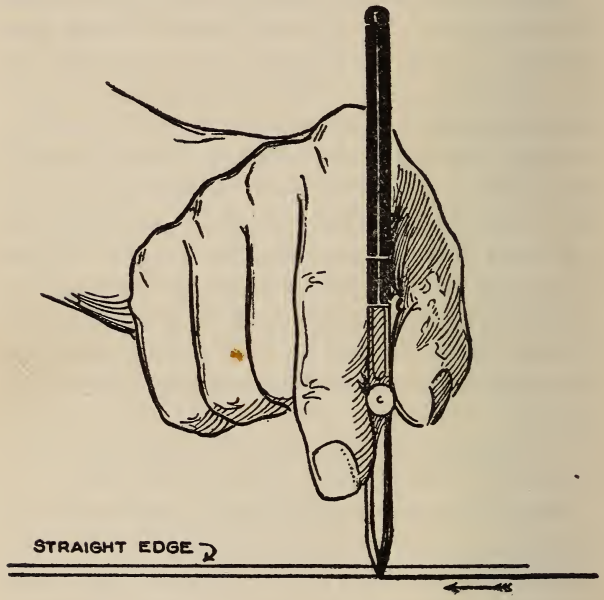
This ruling pen is an invaluable tool to the chartographer. It has two blades or tines the relation of each to the other being controlled by an adjusting screw. The manipulation of this screw permits the drawing of lines of varying widths. The use of the ruling pen should be confined to line and curve work. Some pens have a lever attachment which permits the cleaning of the tines without disturbing the gauge at which they may be set. This lever saves the time required to make the proper adjustment again and prevents the possibility of the chartographer resuming work with a different adjustment of the tines.

CORRECT POSITION FOR HOLDING PEN

The ruling pen should be held in such a position as to be in a plane perpendicular to the surface of the drawing sheet, the tips of the thumb and forefinger grasping the pen at the adjusting screw. This is illustrated on the following page.

Holding the pen in this way permits, when necessary, the manipulation of the screw by slightly raising the pen from contact with the

sheet. In ruling lines or curves the hand or fingers should not touch the paper, nor should the elbow rest on the sheet. The movement of



the pen is not from the hand but is a free elbow movement and is from left to right and from bottom to top of the sheet.

Failure to observe these instructions will result in the points of the tines wearing away unevenly and the pen then develops what is referred to by draftsmen as a "shoulder." This usually means that this particular pen must be discarded for line and curve work as it is no longer a "true" instrument or tool. These old pens can be used to advantage, however, in filling in bars, they being operated in such cases somewhat as one would a small brush. It is not impossible to remove a "shoulder" from a ruling pen. This can be done by using a small oil-stone or razor-hone. The stone or hone can also be used to advantage in keeping the points of the tines sharp and true. In this process of sharpening be careful to hold the ruling pen against the surface of the stone or hone at an angle of about forty-five degrees, grinding the points with a gentle rotary motion. Follow this by rubbing the points of the tines on any glass surface. An examination of the points should then find all "burrs" or unevenness to have been removed.

PEN POINTS

In addition to the ruling pen and as a substitute for it in many uses, the student will need pen points and, of course, a penholder or holders. For fine line work and small lettering Gillett's

No. 303 is recommended. Esterbrook's No. 14 bank pen point is also good for lettering. Gillett's No. 291 will also be found satisfactory, especially in mapping work.

The student is no doubt familiar through personal experience with the fact that most pen points when first dipped in ink repel or throw off the ink. This is likely to result in blots or spots if it occurs on a sheet of drawing paper. To obviate this it is suggested that the pen point be held for a moment in the flame of a match before being put to use for the first time.

THE DRAWING BOARD

The effective use of the section paper, the pencil, the ruling pen, the pen points, and the ink makes necessary that the student also have a drawing board. This is nearly always made of neatly glued strips of soft wood, usually white pine, with a hardwood ledge of an inch or so on each end. The board can be secured in varying sizes ranging from 12 by 17 inches to 31 by 42 inches. Larger sizes can also be purchased. The board rests unattached on the desk or table and can be moved about freely with the section paper temporarily attached to it by means of thumb tacks. In case the student prefers a drawing table, this can be had in various makes and designs.

THE T-SQUARE

The drawing board or table facilitates greatly the use of the T-Square, another tool of the chartographer which he will find invaluable. It is so-called because of its resemblance to the capital letter T. For all purposes of accurate line drawing not involving measurement it supplants the ordinary ruler. A T-Square fitted with transparent ruling edges is recommended, as it permits the draftsman to see adjacent portions of the section sheet that would be hidden if a wooden straightedge were used. It fits in snugly and along either ledge of the board or table accurately by reason of the head piece of the T-Square extending beneath the blade with its ruling edges. This permits of a true base line as well as other horizontal lines. Upon this base line, with the T-Square in position, true vertical lines are erected by means of the Triangle.

THE TRIANGLE

The use of the Triangle is largely confined to making vertical and horizontal lines. Do not attempt to draw these lines with the ordinary ruler if any degree of accuracy is desired as such an attempt will most likely result in inaccuracy. Accuracy, it should be remembered, is one of the cardinal principles of good chartography.

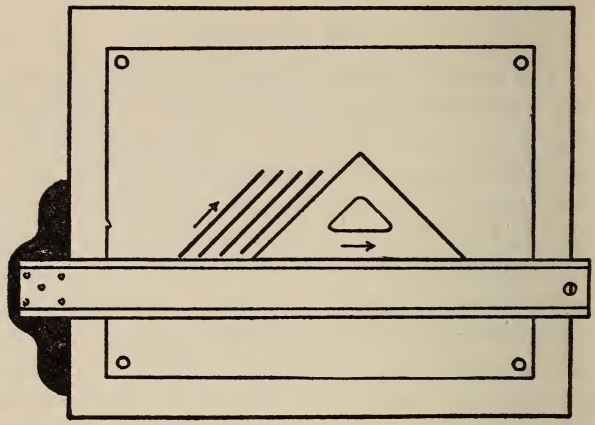


FIG. 1

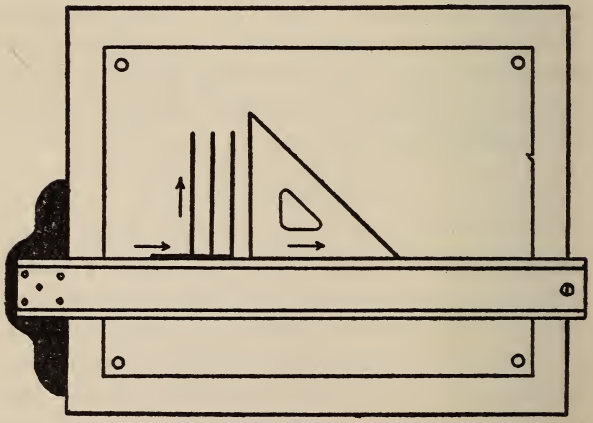


FIG. 2

The illustration on the preceding page shows some of the uses to which the Triangle is put when operated in connection with its running-mate, the T-Square. Triangles are obtainable in numerous sizes and angles, the standard angles being 45 degrees and 30 by 60, the latter commonly called "Thirty" by draftsmen.

THE ENGINEER'S SCALE

Important uses will also be found in chart making for the engineer's rule or scale. It is an equilateral triangle in shape, that is, all its sides are equal; it is usually made of hardwood, 12 inches in length (although different lengths are procurable), and has three edges each with two measuring surfaces. These six surfaces are laid off into multiples of 10, with 10, 20, 30, 40, 50, and 60 units to the inch, and in consequence they provide measurements of almost any fraction of an inch that can be quickly applied to varying scale units of less than an inch. The engineer's scale is admirably adapted to linear measurements, that is, to measurements pertaining to or of the nature of a line or in one direction.

The engineer's triangular scale is not to be confused with the architect's triangular scale, the latter having the inch divided into units of fourths, eighths, sixteenths, thirty-seconds, and so on,

and which is of little use to the chartographer. The student is cautioned against making use of the engineer's rule for ordinary ruling purposes, as this use wears away the ruled edges and in time makes ineligible the sub-divisions of the inch.

THE DIVIDERS

Assistance in the drawing of a chart is also rendered by the use of the compass or dividers. It consists of a handle from which extends two prongs each having a sharp point. In the handle is a joint, either a pivot or tongue, which permits adjustments between the two points up to several inches. This enables the draftsman to "step-off" or gauge accurately any measurements on lines or charts that are to be transferred to other lines or charts. Greater accuracy will be secured from the use of the dividers than from that of the ordinary ruler for this purpose.

Every draftsman has use for kneaded rubber, art gum, and the "ruby" or red rubber eraser for erasure purposes. A hard rubber or gritty eraser, such as the ordinary typewriter eraser, should not be used. A supply of pins, clips, thumb tacks, and the like will also come in handy.

THE ESSENTIAL TOOLS

The following summarizes the more important tools needed in chartography:

One drawing pencil HB.

One ruling pen.

Six Gillett's No. 303 and six Easterbrook's No. 14 pen points.

One bow or compass pen with interchangeable pen and pencil points and extension bar.

One bottle Higgin's waterproof black drawing ink.

One drawing board or table.

One T-Square.

One six-inch celluloid 45 degree triangle.

One twelve-inch engineer's triangular rule.

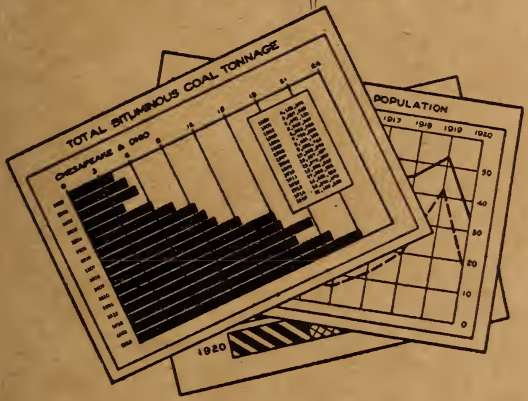
One dividers.

These tools can each be bought separately but a material saving is made by purchasing a complete set of drawing instruments at the outset. The price naturally varies according to the quality but an expensive set is not necessary for good work. The outfit of the chartographer may be simple or elaborate according to individual taste. A few well selected instruments of standard make is recommended at first. Where the beginner confines himself to a limited number of tools he becomes familiar with the "feel" and balance of each instrument and, as a result, soon learns to handle it with confidence and skill. This applies especially to the drafting or ruling pen.

QUESTIONS FOR SELF-EXAMINATION

1. What is cross section or coordinate paper? What service does it perform in chartography?
2. What is the function of the lead pencil in chart making?
3. What is the ruling pen? Describe the correct position for holding it. What is a "shoulder" and what causes it? How can it be prevented?
4. Describe the drawing board and its uses.
5. What is the T-Square and what are its uses? The Triangle?
6. What is the engineer's scale? How and for what purposes is it employed?
7. Describe the dividers and its uses.
8. What are the essential tools in chartography?

CHARTOGRAPHY
IN TEN LESSONS
BY FRANK J. WARNE



LESSON VII

ACCURACY IN CHARTOGRAPHY

PUBLISHED BY
FRANK J. WARNE
SOUTHERN BUILDING
WASHINGTON, D. C.

LESSON VII

Accuracy in Chartography

The Use of the Typewriter—Drawing Letters for the Title—Exaggerating the Curve—Effects of Exaggerating the Curve—Advantages of Extra Squares.

In placing on the chart the figures of the scale lines, the statistical table, the foot-notes, and other figures and letters the use of the typewriter enables the chartographer to meet many of the exactions encountered in the practice of his art. This is especially true when a large number of different charts has to be made for reproduction in quantities by means of one of the photographic processes.

THE USE OF THE TYPEWRITER

If a long-carriage machine is not available and if the coordinate sheet is too large for the ordinary typewriter the sheet can be cut in two and afterwards pasted together. This makes necessary the exercise of care in handling the sheet afterwards or else the typewritten figures will "rub." This work on the typewriter should be done after the lines and curve or bars are completed.

Another practice that has many advantages is

first to typewrite the numbers and words on separate slips of paper and then paste these securely in their proper places on the section sheet. This plan should be followed if the chart is to be reproduced. It enables corrections to be made more easily and does not wrinkle or otherwise damage the sheet. If the chart is not to be reproduced, the letters and figures should be written according to the first plan, that is directly on the coordinate sheet itself.

Typewriting the table directly on the chart or on a separate slip of paper and later pasting this on the sheet, requires considerable painstaking care. The typed figures and letters must be clean, decimal points separating the digits must be in column order equally exact with the fig ıres themselves, units of tens or hundreds and so on must be under each other, and all in straight columns with headings appropriately placed at the top of each. In pasting the slip on the sheet exactness is required so as to avoid the appearance of "skewness." Corrections can more easily be made with the figures and letters on the slip than with them directly typed on the coordinate sheet.

In the employment of the typewriter for placing words and numbers on a chart that is to be reproduced by a photographic process, care must

be exercised in seeing to it that the ink of the typewriter ribbon is of a quality that will reproduce. I know of the experience of a fellow chartographer who had in progress a rush contract for several hundred different charts on each of which was to be reproduced a statistical table. He failed to have proper attention given to overseeing the typing of these tables, with the result that not one would reproduce because the right kind of ink was not used, In itself the kind of ink may be a small matter but the consequence of not using the right kind is likely to prove serious and costly.

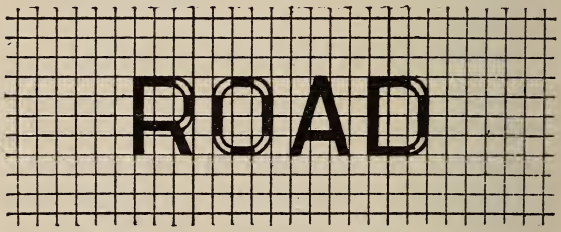
DRAWING LETTERS FOR THE TITLE

Virtually all the figures and letters required on a chart can be placed in their proper positions by means of the typewriter with the exception of the title letters. These latter are usually larger than those of the typewriter, although even for the title the capitals of the typewriter can sometimes be made to serve the requirements. As a general thing, however, the use of the typewriter for the title letters is inadvisable.

It is this lettering for the title that is among the exactions of chartography with which the beginner is likely to have some difficulty. He must learn how to make the kind of letters required. This is not so difficult as might at

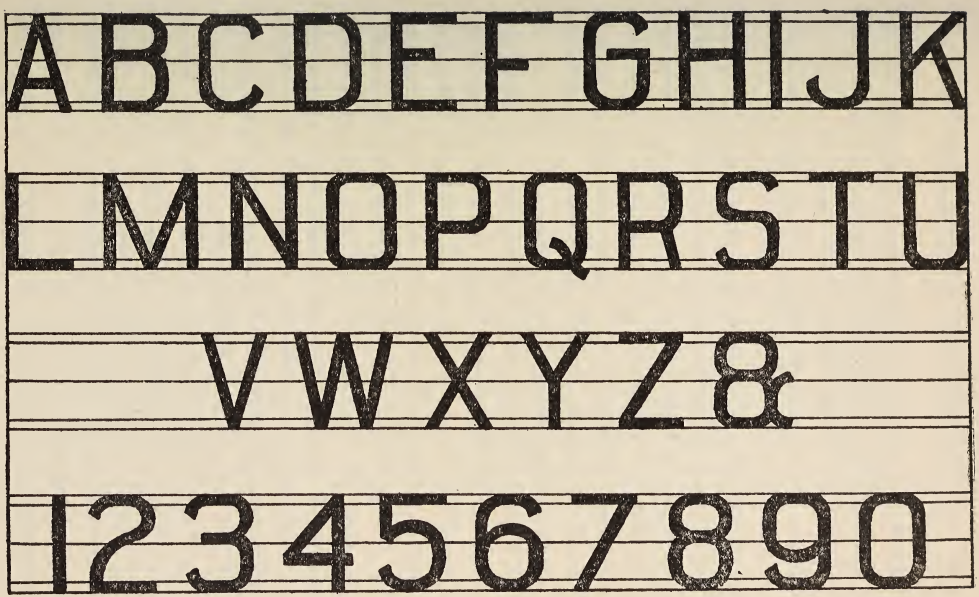
first appear; in fact it is quite simple, and by a little practice the student can soon become proficient in this phase of the work.

In making these larger letters the minute squares of the coordinate sheet are of material assistance. After determining upon the size of the letter required, the horizontal and vertical lines of each letter are drawn by the ruling pen and with the aid of the minute squares. The curved corners are first left blank, as illustrated in the following:



Then the curved corners are filled in with a free hand pen.

For the guidance of the beginner in chartography the letters of the alphabet are reproduced on the opposite page as samples of plain and easily made letters based upon the above instructions as to how they are to be drawn. No attempt is made to present other than a simple utility alphabet, all the letters with the exception


ABCDEFGHIJK
LMNOPQRSTU
VWXYZ&
1234567890

of I, M, and W being approximately of the same width. Illustration is also given as to the drawing of large figures.

EXAGGERATING THE CURVE

The beginner in chartography, however, should know how to make letters and should not neglect to become proficient in this direction. Practice in lettering teaches painstaking accuracy, and this is demanded of the good chartographer. In chart making he will have many opportunities for acquiring this personal asset.

Especially is this true in the process of determining and plotting the scales for the curve chart. He must be certain that his vertical scale does not permit of the exaggeration of the movement of the curve. This exaggeration easily results in not allowing for the vertical scale the same amount of space per each scale unit as for the horizontal scale, and vice versa. In other words the movement of the curve can be exaggerated either vertically or horizontally.

"The scales of any curve chart should be so selected," says Brinton, in *Graphic Methods for Presenting Facts*, "that the chart will not be exaggerated in either the horizontal or the vertical direction. It is possible to cause a visual exaggeration of data by carelessly or intentionally

selecting a scale which unduly stretches the chart in either the horizontal or the vertical direction."

"The beginner in curve plotting and in curve reading," continues Brinton, "is apt to be somewhat puzzled by the different effects which may be obtained by changing the ratio between the vertical scale and the horizontal scale. It is difficult to give any general rules which would assist in overcoming the beginner's confusion. Ordinarily the best way to get facility in making the proper choice of vertical and horizontal scales for plotting curves is to take one set of data and plot those data in several different ways, noticing the changes which the different scales selected give in the proportions of the chart. Just as the written or spoken English language may be used to make gross exaggerations, so charts and especially curves may convey exaggerations unless the person preparing the charts uses as much care as he would ordinarily use to avoid exaggerations if presenting his material by written or spoken words."

"A person reading charts must take great care," concludes Brinton on this point, "that he does not give too much weight to the actual appearance of the curve on the page, instead of basing his conclusions on the percentage increase or decrease as judged from the figures of the ver-

tical scale. The proper choice of scales for curve plotting is largely a matter of judgment, and the judgment can be trained very greatly if it is kept in mind to examine every curve chart which comes to one's attention to see whether the vertical and horizontal scales have been selected so that the chart gives a fair representation of the facts."

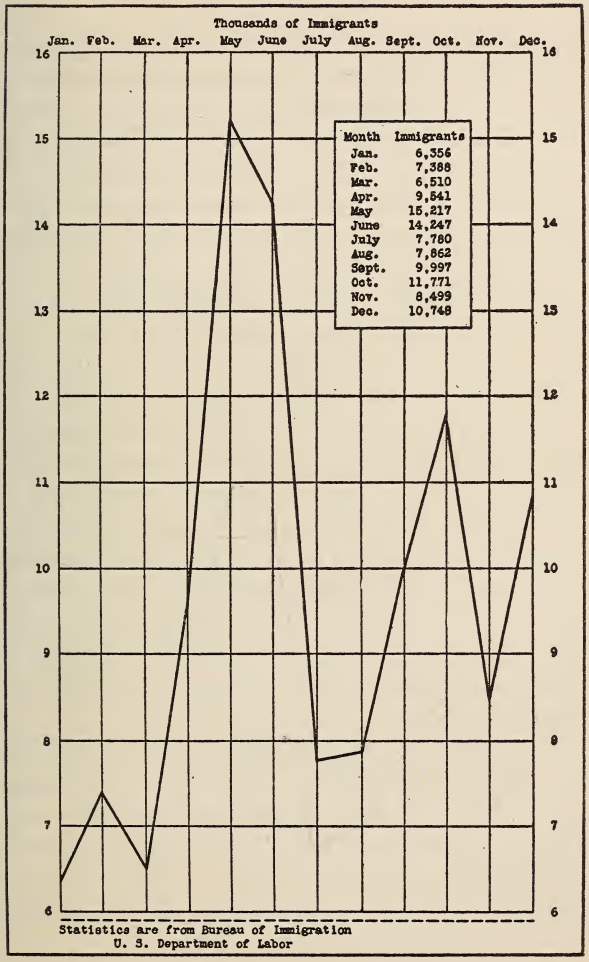
EFFECTS OF EXAGGERATING THE CURVE

The effects of an exaggeration of the vertical scale can be seen from a study of the chart on the opposite page. The units of the vertical scale are there purposely made twice the distance apart than are units of the horizontal scale. The result is an exaggeration to the eye, in the rise and fall in the movements of the curve across the sheet, of just twice what these movements should be.

In order that the student may comprehend clearly for himself just what this exaggeration of the curve means, it is suggested that he draw on the chart on page 89 in light lead pencil a broken or dash curve that conforms to a scale by which the distance between the horizontal lines is reduced one-half. In other words, he is to give to each horizontal and vertical scale unit exactly the same space.

Rearranging the vertical scale units accordingly the unit 7 falls on the vertical line at a point half

IMMIGRATION TO UNITED STATES BY MONTHS, 1918



way between the unit 6 and the present 7, and the point now marked by the latter becomes the place for the scale unit 8. Proceeding upward in this manner cross out with the lead pencil each of the old vertical scale units and substitute the new units according to the revised plotting. Reproduce in lead pencil this new scale also alongside the extreme right vertical line. Connect these new left and right vertical scale points by horizontal lines in light lead pencil. Next draw the curve from point to point of the vertical lines as determined by the revised units.

It will now be found that this new curve moves up and down exactly one-half the distance of the original curve. The new curve starts at a point on the left vertical line just above the present scale designation 6 and ends at a point on the right vertical line half way between the present scale units 8 and 9. These vertical scale units represent thousands of immigrants, as explained in the word designation just above the horizontal scale line.

It is important to remember in connection with the exaggeration of the curve that the arbitrary limitations of space imposed upon the chartographer does not permit him in every case to choose the scale that might have been chosen if there were no factors to consider other than the exact

presentation of the statistics. His problem is to present the facts as clearly as possible within the arbitrary limitations of space imposed upon him. Sometimes he will find himself in a quandary in his endeavors to include all the necessary data without exaggerating one or the other of the scales.

ADVANTAGES OF EXTRA SQUARES

Reducing by one-half the space allowed the vertical scale unit in the chart on page 89 brings the lowest and the highest points of the curve within a space of less than three inches, thus decreasing horizontally as compared with the old curve the size of the area within which the curve moves without affecting its size vertically. Plotted in this way results in an awkward size for the chart.

This can be overcome by providing at least two series of squares both below the lowest and above the highest points recorded by the movement of the curve. In such cases the vertical and horizontal lines forming the squares are drawn just as if they were to be used to indicate a stage in the movement of the curve. This extension of the area of the squares should also be regulated so as to accommodate the placing of the statistical table without crowding. It will nearly always be found feasible in plotting the vertical scale to

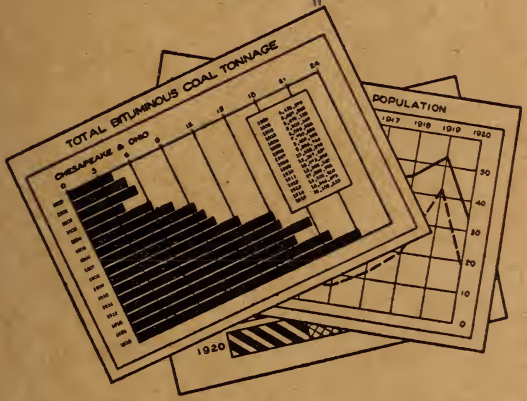
provide for at least one series of squares vertically into which the movements of the curve do not enter. This will be found to be advantageous in a number of ways. It adds to clearness of expression as well as avoids the appearance of crowding.

If the exaggeration of the scale in the chart on page 89 had been in the horizontal instead of the vertical measurement, just the opposite effects to those noted would have resulted. It is suggested that the student draw a chart in which he gives twice the space to the horizontal scale unit that he gives to the vertical scale unit, using the data in the statistical table of the chart on page 89.

QUESTIONS FOR SELF-EXAMINATION

1. Describe the various uses of the typewriter in chartography.
2. How are large letters drawn by hand?
3. How is the curve exaggerated? What are some of its effects? How can these be avoided?
4. What are the advantages of extra squares?

CHARTOGRAPHY
IN TEN LESSONS
BY FRANK J. WARNE



LESSON VIII

CURVE AND BAR DESIGNATIONS

PUBLISHED BY
FRANK J. WARNE
SOUTHERN BUILDING
WASHINGTON, D. C.

LESSON VIII

Curve and Bar Designations

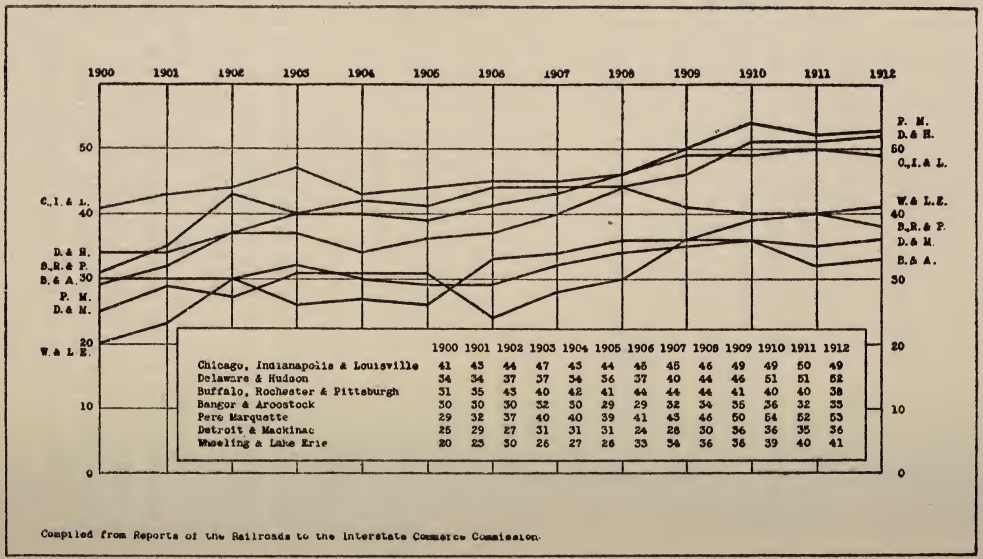
Disadvantages of the Unbroken Curve—Curve Designations—Word Designations of Curves—The Peak-Top Curve—Determining the Scale Spacing—Utility of the Curve Chart—Chartography Based on Comparisons—Bar Designations—Interpreting the Bar—Some Characteristics of a Good Bar Chart—Word Designation of Scale Units.

It is plain that if a number of curves on the same chart are each drawn as an unbroken curve much confusion will accompany efforts to interpret the tendencies shown, as most likely the curves cross and re-cross each other. This is illustrated in the chart on the following page.

DISADVANTAGES OF THE UNBROKEN CURVE

Let the student try to follow each curve from its beginning on the left vertical scale line to its termination on the right vertical scale line. It is hardly possible that he accomplishes the task successfully in every case by ending on the curve he starts out upon, as indicated by the initial abbreviation of the name of the railroad. Even if he does succeed he will have spent a great deal

AVERAGE NUMBER OF PASSENGERS PER MILE



	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911	1912
Chicago, Indianapolis & Louisville	41	43	44	47	43	44	45	45	46	49	49	50	49
Delaware & Hudson	34	34	37	37	34	36	37	40	44	46	51	51	52
Buffalo, Rochester & Pittsburgh	31	35	43	40	42	41	44	44	44	41	40	40	38
Bangor & Aroostock	30	30	30	32	30	29	29	32	34	35	36	32	35
Pere Marquette	29	32	37	40	40	39	41	43	46	50	54	52	53
Detroit & Mackinac	25	29	27	31	31	31	24	28	30	36	36	35	36
Wheeling & Lake Erie	20	23	30	26	27	26	33	34	36	36	39	40	41

Compiled from Reports of the Railroads to the Interstate Commerce Commission.

more time than should be required to interpret such a chart correctly. Among the aims of chartography is to prevent confusion and to aid comprehension at a glance, and the reading of a chart should not have placed in the way obstacles like those illustrated on the opposite page, especially when the obstacles have no reason or even excuse for being. A study of the chart should quickly convince the student of the disadvantage of using the same kind of unbroken curve for two or more statistical elements on the same chart. Reading the chart in question is only slightly aided by placing at the left and right vertical scale lines the abbreviations of the names of the different railroads which the curves represent.

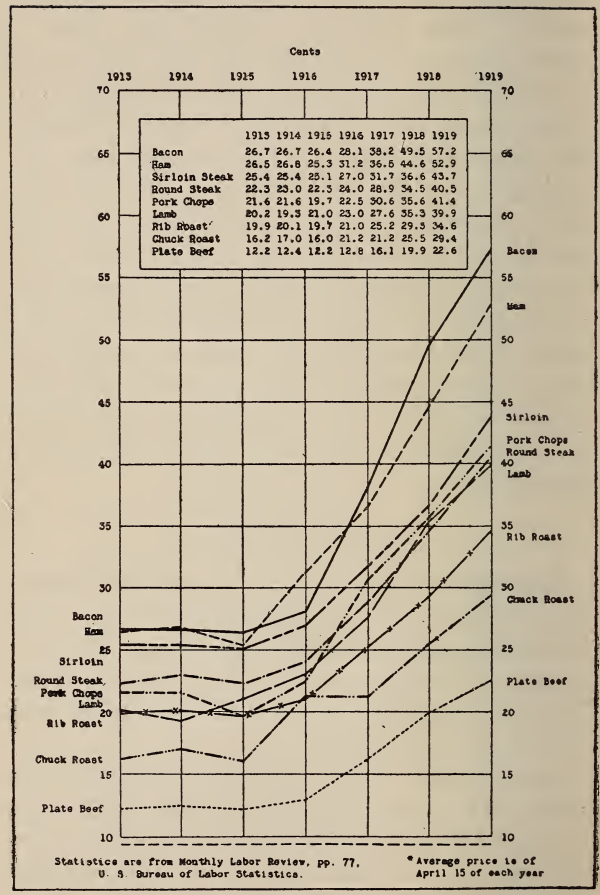
CURVE DESIGNATIONS

Attention is thus called to a practical condition confronting the chartographer which would be replete with difficulties did he not have recourse to a simple device to overcome them. This is the employment of different designations for two and more curves.

In contrast with the unbroken or straight line curves of the chart on page 94, those of the chart on page 96 should be studied. The latter compare as many as nine separate and distinct sta-

AVERAGE PRICES* OF MEAT PRODUCTS

UNITED STATES, 1913-1919



Statistics are from Monthly Labor Review, pp. 77, U. S. Bureau of Labor Statistics.

*Average price is of April 15 of each year

tistical elements, presenting two more curves than are in the chart on page 94, and yet there is not the slightest difficulty or confusion in tracing the nine curves from their beginning to their termination. This greater clearness and ease of interpretation is almost entirely due to the fact that a different designation is given to each curve. If this had not been done it would be almost as difficult to follow the curves in the chart on page 96 as in the chart on page 94—the curves of the former would also be lost, as to the reading of their movement, at the points where they cross and re-cross one another.

Quite frequently the student of chartography will encounter the problem of having many curves to compare. While this difficulty is met in part by employing different designations for the curves, there will be occasions when even this method will result in confusion. Under such circumstances, instead of attempting to draw all the curves on a single chart, it will be found advantageous to make two or more charts. One set of the group of figures should be selected as a common basis for the comparison and the curve representing this set or statistical element inserted on all the charts, this curve taking the same unbroken or straight line designation on each chart. It is a mistake to place a larger

number of curves on one chart than can be read quickly and without confusion to the eye in tracing their movements. Where the curves lie close together or are constantly crossing and recrossing each other, more than five or six are likely to result in this confusion.

It is in making clear just such problems as those presented in the chart on page 96, where a number of different statistical elements must be compared, that the advantage of the curve method over the statistical method becomes apparent. To grasp quickly and comprehendingly the meaning of each of the nine different columns of figures, not only in relation to its own element over the period of years but also in relation to each of the elements of the other eight columns, is practically an impossibility to most minds. And yet one of average intelligence can easily read the trend or tendency of these prices of different kinds of meats when interpreted by the curves.

WORD DESIGNATIONS OF CURVES

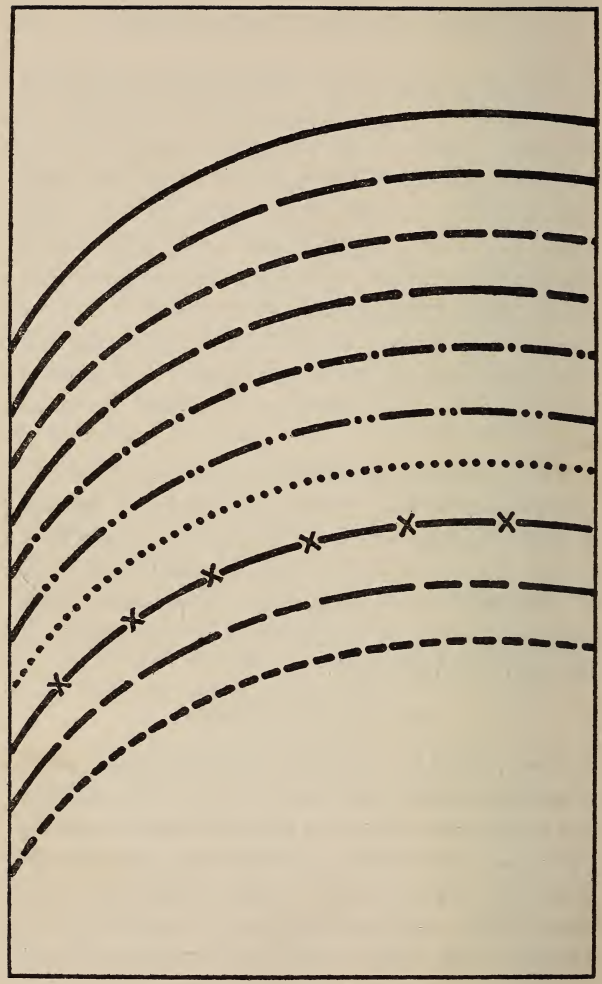
Not only from the point of view of interpretation but also of mechanical construction the chart on page 96 is recommended for close study. Note the word designations of the curves to the left and right of the vertical scale lines. This insertion of the word designation alongside the point

of contact of the curve with the vertical scale lines lends to easy reading of the chart. It requires, however, extending the space between each vertical scale line and its respective neat line, and this is not always possible. In such cases the curve designations with their word descriptions should be placed at some convenient place on the framework itself as a sort of key or legend. Quite frequently a good place for the legend will be found to be just beneath the bottom horizontal line and above or between the footnotes.

The different designations that can be employed for curves should be practiced by the student until he has acquired facility in drawing them. To assist him in this the following page of designations is presented. These have been made considerably larger than is necessary for the curve on the chart.

THE PEAK-TOP CURVE

The student is cautioned against making use of what is called the "stairway" curve. This makes a flat or step-like contact at the point determined by the scale. All curves, as has been said, should approach the point of contact slantingly and direct from the point previously touched on the vertical line. The great advantage of this



peak-top curve is brought out on charts containing two or more curves which approach each other at or near the same points. In such cases the peak-top permits of easy separation of the two curves and does not result in confusion caused by inability to follow the curves, which latter is inevitable when two flat-top or stairway curves approach each other at the scale unit points.

DETERMINING THE SCALE SPACING

In determining the vertical space a number of curves should occupy every one of the columns of figures in the statistical table is examined to ascertain the lowest and highest numbers that are to be charted. That is, for this purpose all the different columns representing the comparable statistical elements are considered as if they were only a single column.

Take, for illustration, the table of the chart on page 96. The lowest number of cents represented in any one of all seven columns is 12.2 in the column for the year 1913. This number also appears in the column for the year 1915. The largest number of cents in any one of all the columns is 57.2 in the column for the year 1919. Thus the spread for all the numbers in all the columns is from 12.2, the price of plate beef in 1913 (also in 1915), to 57.2, the price of bacon in 1919, or a max-

imum spread for all the figures of 45. With a vertical scale unit of 5 this spread requires at least ten squares vertically with the base line starting at the unit 10. Starting at 0 would require two additional squares below the scale unit 10, but if this were done there would not be space enough anywhere on the framework for the inclusion of the statistical table. Our squares are thus more valuable at the top, so we provide two additional there to accommodate the table.

UTILITY OF THE CURVE CHART

By this time the student should have become impressed with the great utility of the curve method in chartography. In comparing the tendency over a period of time of two or more distinct but related statistical elements it is far superior to the bar method in chart making and incidentally is also superior to the statistical method. While a trained statistician could interpret satisfactorily the tendency from a study of columns of figures, no one else could perceive the movement as clearly as it is convincingly demonstrated by curves drawn in relation to each other.

This is particularly true when more than two curves representing different columns of figures are compared, as in the chart on page 96. These curves not only show the variations in each of the

items for each year compared with the other years and with the other items but they also give a comprehensive perspective of the entire movement during all the years; they show the status of each of the items in relation to every other item for each year and at the beginning and through to the end of the period of time. Thus it is that chartography can be said to "speak" a language easily made intelligible to the mind through the eye.

CHARTOGRAPHY BASED ON COMPARISONS

The curve also strikingly emphasizes the fact that the art of chartography is based upon relations or comparisons. There can be no chart without a comparison of some kind. And as the very nature of statistics involves a relation between or a comparison of groups of facts, it is not too much to say that chartography is the art best adapted to expressing this clearly and concisely.

"Comparison is, in general, the final goal toward which all statistical studies tend," says King, in his *Elements of Statistical Method.* "Comparison is necessary to give us clear ideas of the relationship of things in time and space. It is also essential in determining whether phenomena are connected or independent and in establishing relations of cause and effect. We may wish to

study: 1. Changes of a single variable. 2. The structure of different groups. 3. Changes in two or more variables."

Brinton, in his *Graphic Methods for Presenting Facts*, puts it this way: "One of a business man's chief assets is his ability to show things to others in their true proportions. He is continually making contrasts, and holding up for comparison different propositions which come up in his daily affairs. The graphic method lends itself admirably to use in making comparisons. It is surprising how much clearer even simple comparisons of only two or three items will appear when their numerical value is put in graphic form rather than in figures."

In every chart, then, a comparison or relation of some kind is involved. This comparison may be with the same statistical element for two or more periods of time; it may be of two or more different elements for the same or different periods of time. It may be a comparison of total or absolute amounts, of increases or decreases, of the rate of change. It may be a relation of one or more elements expressed in proportions to a common total, and so on.

Graphic methods must, of course, show comparable facts only and these in their true relations and proportions in order to present the correct sit-

uation. They represent the best known scheme for presenting contrasts and in this way indelibly impressing their significance upon the mind. Having recourse to curves differently constructed permits some of these comparisons to be made much more clearly than if the chartographer were limited to the unbroken or straight line curve.

BAR DESIGNATIONS

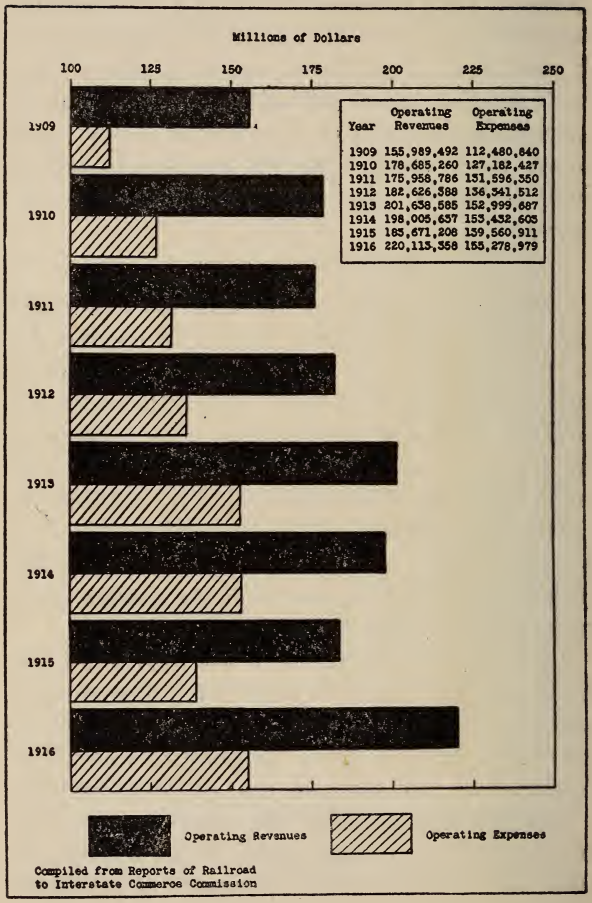
Different designations for different statistical elements or factors apply with equal significance to the bar as to the curve chart. The simplest designations are plain black and white which are usually employed where only two groups of figures or statistical elements are involved. The plain white bar is secured simply by outlining it on the section sheet and without filling it in with the ink. But it is not as satisfactory as a cross-hatched bar, that is, one with the outline filled in by drawing light diagonal lines.

One use of designations in bar charts is illustrated in the chart on page 106. The student should write out on paper a careful analysis of this chart, not only from the point of view of its construction but also from that of interpretation.

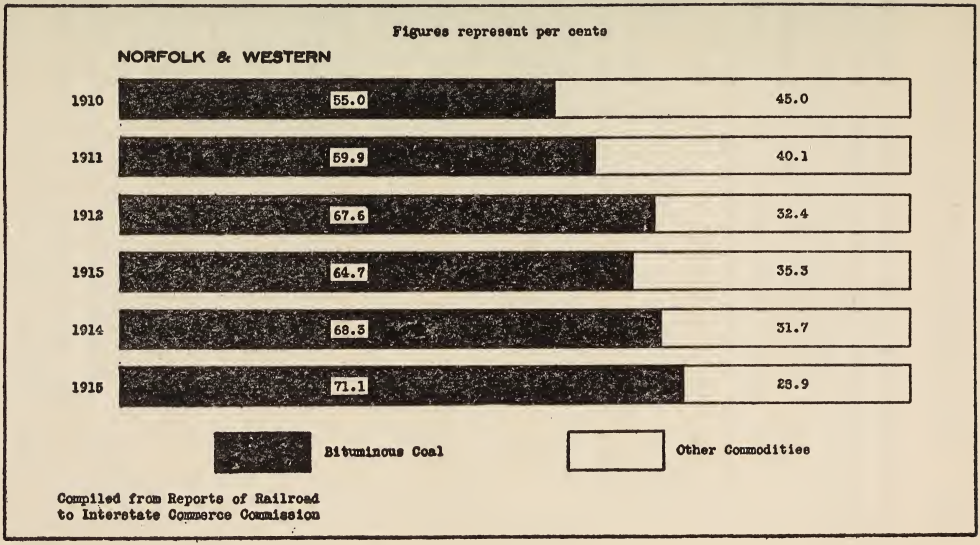
Another and probably the most common use of designations in bar charts is illustrated on page 107. It shows the employment of the black

OPERATING REVENUES AND EXPENSES

PENNSYLVANIA RAILROAD



RATIO OF BITUMINOUS COAL TO OTHER COMMODITIES CARRIED



Compiled from Reports of Railroad
to Interstate Commerce Commission

and white as parts of a whole bar. In this chart the total freight traffic of the Norfolk and Western Railroad Company has been separated on the percentage basis between bituminous coal and all other commodities transported. The comparison involved is expressed as a ratio. The changes over the period of years of the coal traffic in relation to the total traffic, as well as also in relation to the traffic in all other commodities, is seen by comparing the black portions of the bars with the total bars, reading from left to right. Similar changes in the proportion of the traffic of other commodities to the total freight traffic is shown by comparing the white portions of the bars with the total bars, reading from right to left in order better to secure an idea of the differences in the length of the white sections. The proportion of each designation to the total bar in any one year and the changes as between years are clearly indicated.

In this chart each of the series of horizontal bars represents by 100 per cent the total amount of all freight traffic for each of the designated years. Consequently all the bars are of the same length. No information is given as to the numbers representing the absolute amount of traffic of the road, which it may naturally be assumed varied in the different years—it may

have increased or decreased from year to year and if these numbers were charted they would likely give bars of varying lengths. All that the chartographer is interested in, so far as the statistics enlighten him, are the changes in the proportion of the two components which together comprise the total freight traffic for each year.

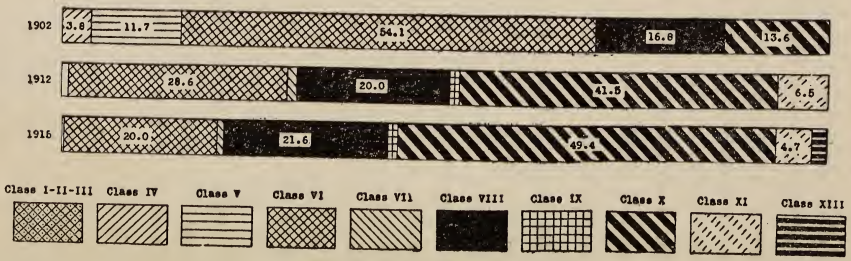
SOME CHARACTERISTICS OF A GOOD BAR CHART

The chart on page 107 is a good illustration of this kind of a bar chart. The title is concise and yet comprehensive. The sub-title—that of the particular railroad—is well placed and well spaced. The figures for the years are directly under each other and are spaced sufficiently from the bars, while the figures for the black and white portions of the bars are directly in proper column form on each of the six bars. The reader is told at the top of the framework that the figures represent per cents, and at the bottom among the foot-notes that the statistics have been "Compiled from Reports of the Railroad to Interstate Commerce Commission." The group of bars is so spaced as to avoid the appearance of crowding. The designations of the bars are clearly distinguished between "Bituminous Coal" and "Other Commodities" by means of the legend beneath the bars. The neat lines properly frame the series of bars.

DISTRIBUTION OF TONNAGE CAPACITY OF FREIGHT CARS

Figures represent per cents

BALTIMORE & OHIO



Compiled from Reports of Railroad
to Interstate Commerce Commission

When more than two statistical elements have to be indicated on a bar the chartographer has recourse to an almost unlimited number of different designations. Some of these, shown in the chart on the opposite page, indicate the extent to which variation in bar designations can be carried. The effect of the use of these different designations is for the purpose, of course, of causing the areas to stand out in contrast with each other. The student should practice until he becomes proficient in making these designations.

In the chart on page 89 (Lesson VII) and in the one on page 106 will be found a simple device and yet a valuable aid to chartography. This is the word designation of the vertical scale unit of a curve and the horizontal scale unit of a bar chart.

In the chart on page 89 (Lesson VII) this designation is "Thousands of Immigrants." By its use the chartographer is able to drop from each of the vertical scale units all the ciphers representing thousands. That is, instead of the vertical scale starting with the unit 6,000 it begins with 6, the interpreter of the chart knowing from having read the word designation that this unit 6 means 6,000. So with the horizontal scale unit of the chart on page 106. There the word designation is "Millions of Dollars" and this permits the drop-

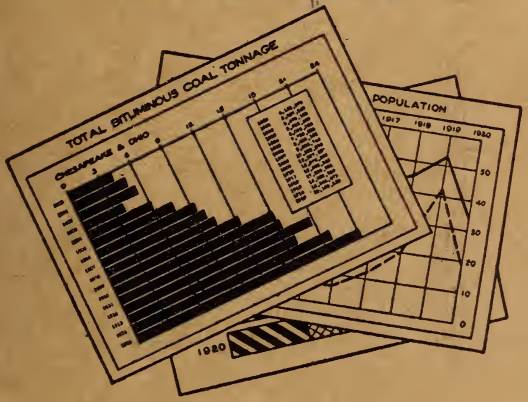
ping of six ciphers from each of the horizontal scale units—it allows the scale to begin with the unit 100 instead of requiring 100,000,000. To reproduce the additional six ciphers after each one of the horizontal scale units would overburden the horizontal scale line with figures even if space could be found for all of them.

Making use of the word designation of the scale so as to drop the ciphers from the scale line itself has many advantages and should always be employed where the numbers represented are more than three digits, that is, thousands and over. The designation should be clearly presented in an easily observable place on the chart, even when the table of figures would seem to make this unnecessary, so that the chart can be quickly read and easily understood without reference to the statistics from which it is made. Usually the best position for the word designation is just beneath the top neat line and centered above the horizontal scale line.

QUESTIONS FOR SELF-EXAMINATION

1. What are the advantages of various designations for different curves?
2. Describe the peak-top curve.
3. How is the scale spacing determined?
4. Describe the utility of a curve chart.
5. What is the basis of chartography?
6. Discuss the uses of various designations for different bars.

CHARTOGRAPHY
IN TEN LESSONS
BY FRANK J. WARNE



LESSON IX

STATISTICS AND CHARTOGRAPHY

PUBLISHED BY
FRANK J. WARNE
SOUTHERN BUILDING
WASHINGTON, D.C.

LESSON IX

Value of Statistics to Chartography

The Statistical Table—Aids in Reading the Table—The Substitution of Ciphers—The Table of Ratios—Building Up A Table—The Percentage Increase and Decrease—The Zero Line—The Arithmetic Average—The Misuse of the Average—Statistical Class Limits.

It should be clear by this time that a most important asset in the practice of chartography is a knowledge of statistics. The mere mechanical act of drawing lines and curves and bars on section paper is the work of the draftsman and does not of itself make a chartographer. In these Lessons it has been assumed that the information is already at hand in proper form for the drawing of the chart—that the collection and compilation of the statistics have been correctly done and that the figures have been checked and verified so that there is no question as to their accuracy and trustworthiness.

This assumption has been necessary for the reason that statistics are a distinct field of study in themselves, with sub-divisions as to methods of collection, of compilation, of tabulation, of computation, of arrangement, of presentation, of inter-

pretation, and so on. This field is entirely too extensive to be presented in these Lessons even in merest outline, and for a knowledge of its principles the student should have recourse to standard books on the subject. All that can be done here is to make the briefest reference to a few only of its features which most vitally concern the beginner in chartography.

THE STATISTICAL TABLE

Conspicuous among these is the arrangement of the statistical elements in the table. The principles underlying this have necessarily been discussed briefly in preceding Lessons. But there is one other point in particular to which attention must be called. This is the more or less common practice—fortunately it is becoming less common as the rules of good chartography become more widely disseminated and better known—for charts to appear in otherwise first-class publications with the statistical table having the latest date at the top and with the earliest period of time at the bottom of the column.

A chart made from a table arranged in this way reads backwards from the latest to the earliest year. In order to interpret it from the earliest year and in sequence of time it has to be read from right to left, which is the wrong way to

read a chart. Invariably this arrangement is at first glance misread, as the natural inclination of the reader is to assume that years are arranged in proper sequence. Where they are not so arranged too much time is lost before this is realized. The first impression on the interpreter of the chart in such cases is exactly the reverse of that intended and which would have been received by him if the correct method of arranging the statistical elements in table form had been followed. In consequence, one of the fundamental purposes of the chart method of disseminating knowledge is violated. Such a practice should not be indulged in even in exceptional cases.

RECONSTRUCTING THE TABLE

Whenever the chartographer has a table of figures to chart in which the latest year or period of time appears at the top of the column, he should rearrange or reconstruct the table in correct column form with the earliest year at the top before he begins planning his chart.

The justification for presenting the latest year first in the column is that it is of greater importance compared with the other years recorded. As a matter of fact, no one year in a series of years that charts a tendency is of any greater importance than the other years. It may be of greater

importance in the mind of some particular individual or individuals as to the significance of the data it discloses but in itself as a year it is only of equal importance with every other year. Besides, chartography offers other and much better methods for placing emphasis on particular statistical elements.

AIDS IN READING THE TABLE

It may be advisable, where large numbers are the basis of a chart, to substitute ciphers as the last two figures in tens of thousands, the last three in hundreds of thousands, and the last five in millions. By raising or lowering the last preceding digit before the cipher, sufficient accuracy is obtained for the purpose of most charts. The advantage of this is that the ciphers enable the mind to grasp more quickly the significance of the numbers. In financial statements, however, this practice has objections.

Necessary space on the chart for the columns of figures can sometimes be secured by dropping entirely the last three or six digits and substituting at the head of the columns a word description of the amount represented, such as thousands or millions and so on as the case may be. This eliminates the confusion to the eye of numerous digits. While this practice is not only admissible but also advisable in designations of the scales it should

not be allowed to become general in tabulations, not even where the value or volume or quantity is so large as to run into seven or more digits, as long as there is space on the chart to show the complete numbers without crowding.

Assistance in the direction of facilitating the rapid reading of a statistical table and in enabling a quicker grasp of its significance, is rendered in cases of long columns of figures by breaking up the numbers into groups of fives with double the space separating each group. For illustration, instead of presenting the table on the chart like this:

Year	Population
1900	75,994,575
1901	77,747,402
1902	79,365,396
1903	80,983,390
1904	82,601,384
1905	84,219,378
1906	85,837,372
1907	87,455,366
1908	89,073,360
1909	90,691,354
1910	92,309,348
1911	93,927,342
1912	95,545,336
1913	97,163,330
1914	98,781,324
1915	100,399,318
1916	102,017,312

It might better be presented as follows:

Year	Population
1900	76,000,000
1901	77,700,000
1902	79,400,000
1903	81,000,000
1904	82,600,000
1905	84,200,000
1906	85,800,000
1907	87,500,000
1908	89,100,000
1909	90,700,000
1910	92,300,000
1911	93,900,000
1912	95,500,000
1913	97,200,000
1914	98,800,000
1915	100,400,000
1916	102,000,000

These figures represent the population of continental United States as reported by the Bureau of the Census of the United States Government in its bulletin on mortality statistics for 1916. Using them as a basis, the student is instructed to draw with a lead pencil a curve or bar chart, whichever he determines, applying to his task the instructions he has received up to this point.

THE SUBSTITUTION OF CIPHERS

This substitution of ciphers for other digits in large numbers does not affect the accuracy of the chart for the reason that the change made by it in any number is so slight, compared with its total, as to be lost in the results of the application of the scale unit to its measurement. Besides, it has a distinct advantage in that it does not accord to the statistics any greater importance than the method of their compilation warrants. No one who is familiar with the methods of taking or enumerating the decennial census of the population of the United States and of estimating its growth for intermediate years believes for a single moment that this population, say, in 1916, was exactly 102,017,312 to the last digit of accuracy. While no criticsm of these methods is here intended, it is but stating the fact that they are not so perfect as to record to the last figure the exact population. Most statistical tables at best are approximations and do not represent absolutely accurate and indisputable facts to the point of minute measurement.

All that can be expected of chartography is that it indicate clearly the general trend or tendency of statistical elements. The chartographer should be on his guard against permitting the curve or bar to convey an impression of a greater degree of

accuracy than is warranted by the statistical information.

THE TABLE OF RATIOS

In dealing with tables of ratios it is always advantageous to carry the digits at least one place beyond the decimal point. The advisability of this should be so clear as not to need to be discussed. If, for instance, by not including the last digit of the two ratios 67.6 and 32.4 of the 1912 bar in the chart on page 107 (Lesson VIII) each portion of the whole bar falls short of its correct measurement and the total 100 per cent bar is incomplete. It is hardly ever necessary to carry the digits further than two decimals and in most cases one digit beyond the decimal point answers all practical purposes.

Frequently decimals exceeding one-half may be raised to a whole number and under one-half lowered to a cipher. Where the digit is exactly one-half whether it is raised or lowered will depend upon the particular circumstances. Percentages or ratios are a problem in mathematics and it is to that science the student should have recourse for more complete knowledge of the principles involved.

As percentages or ratios are derivative figures it is of advantage, if it does not over burden the chart, to place also on the framework the

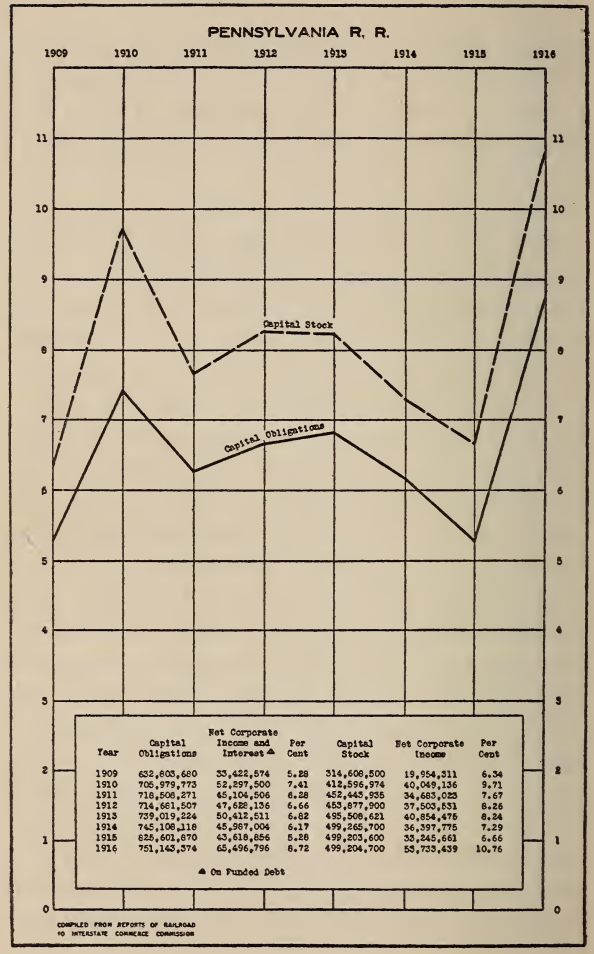
original figures from which they are derived. Where a choice as to exclusion has to be made it should be in favor of the retention on the chart of the derivative figures upon which it is based.

BUILDING UP A TABLE

Both the original and their derivative figures appear in the table of the chart on page 122. This chart also illustrates the use of the curve in expressing ratio. The problem is to show the income of the Pennsylvania Railroad Company in relation to its securities, that is, the rate earned by the latter for each year from 1909 to 1916, both inclusive. The basal information as to securities and income was secured from the annual reports of the company filed with the Interstate Commerce Commission in Washington, D. C.

The amount of bonds representing funded debt and the capital stock were added to ascertain the total of all securities for each of the years. This gives the second column of figures in the table to the chart. In order to ascertain the total income that is properly related to these securities the amount of interest paid on funded debt was added to net corporate income for each year, which gives the third column. This information enables us to ascertain the rate of income each year by dividing the amounts repre-

RATE OF INCOME ON RAILWAY SECURITIES



Year	Capital Obligations	Net Corporate Income and Interest ▲	Per Cent	Capital Stock	Net Corporate Income	Per Cent
1909	632,603,680	33,422,574	5.28	314,608,500	19,954,311	6.34
1910	706,979,773	52,297,500	7.41	412,596,974	40,049,136	9.71
1911	716,508,271	45,104,506	6.28	452,445,935	34,683,025	7.67
1912	714,661,507	47,682,126	6.66	455,877,900	37,503,631	8.26
1913	739,019,224	50,412,511	6.82	495,508,621	40,854,475	8.24
1914	745,108,116	45,967,004	6.17	499,265,700	36,397,775	7.29
1915	625,601,870	43,618,856	5.28	499,203,600	33,245,661	6.66
1916	751,143,374	65,496,796	8.72	499,204,700	53,733,439	10.76

▲ On Funded Debt

COMPILED FROM REPORTS OF RAILROAD TO INTERSTATE COMMERCE COMMISSION

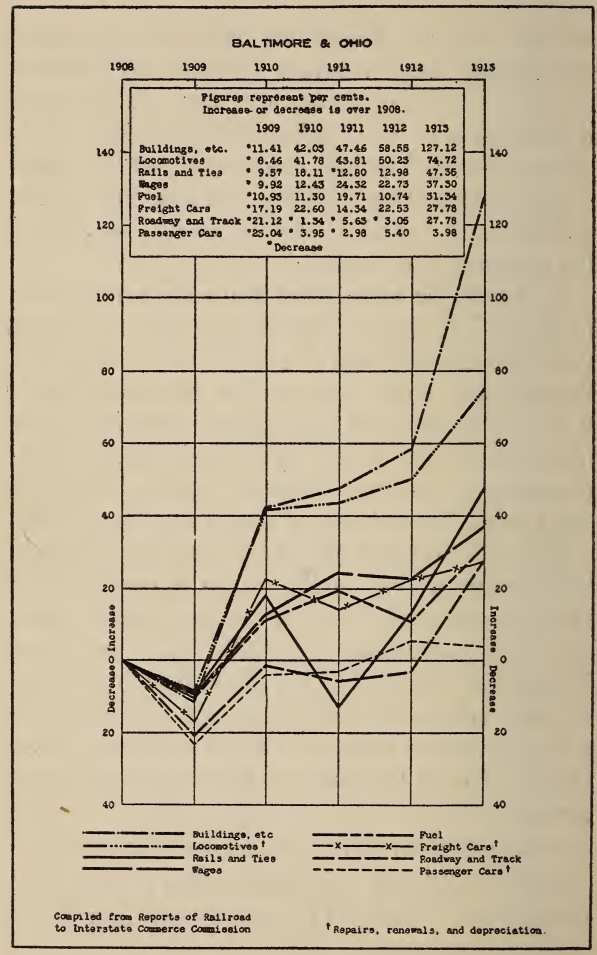
senting capital obligations into the amounts representing net corporate income and interest for each of the corresponding years. The result is the fourth or ratio column of the table. The other column of ratios—the seventh of the table—is ascertained by dividing the amounts representing capital stock into the amounts representing net corporate income.

It should be noted that the only comparison made by the two curves of the chart is based upon the two columns of ratio figures. It would better assist comparison in the statistical table if these two columns were placed alongside each other, but this cannot be accomplished with clearness in reading without making another table with the column of years duplicated and with awkward headings above each ratio column. This latter is due to the words expressing the exact meaning of the ratio column taking up a great deal more space in width than is occupied by the three digits and the decimal point. Thus to place adjacent to each other the columns that are compared is likely to commit an offense more serious than is the value of the advantage to be gained.

THE PERCENTAGE INCREASE OR DECREASE

Quite a different percentage chart is presented on page 124. It shows the rate or per cent of in-

PRINCIPAL ITEMS OF OPERATING EXPENSES, 1908-1913



Compiled from Reports of Railroad to Interstate Commerce Commission

†Repairs, renewals, and depreciation.

crease or decrease. This arithmetical principle is a most valuable aid to the chartographer, for without it many curve charts that are now possible could not be made. This is true in most cases where the difference between the numbers to be compared is considerable, that is, where some are large and the others small numbers, as a chart of these absolute amounts is impossible owing to the requirements of space necessary to indicate the "spread" between the highest and the lowest. But by resolving these varying amounts into per cent increases or decreases, as the figures determine arithmetically, statistical elements are secured which permit of a common measurement and in consequence of a comparison of relative movements over a period of years.

The percentage increase or decrease in our chart of each element for each year from 1908 to 1913 is based upon the amount for 1908. In consequence every curve starts from the same point at zero on the 1908 vertical line, because it is plain that there could be no increase in 1908 over 1908. As the per cent figures for every element show a decrease in 1909 over 1908 every curve extends downward below the zero line to the respective points of contact with the vertical line for 1909. For each of the following years the curves separate more or less widely according to the

tendency as indicated by the figures for the different elements.

Taking the year 1913 for illustration, there is an increase over 1908 in every one of the principal operating expense items. It also shows that the expense of buildings, fixtures, and so on had increased faster relatively than that of steam locomotives, or of rails and ties, or of wages, and so on; that the expense of passenger cars had increased less rapidly than that of any of the other items, and that this expense was greater in 1913 than in 1908.

THE ZERO LINE

The chart on page 124 presents also the zero line feature of chartography based upon percentage increase or decrease figures and not on absolute amounts. It is one that the student is likely to have frequent occasions to make use of. This line is indicated by the cipher designation on the vertical scale lines.

The zero line is in reality the base from which the curves move up or down as the numbers of the statistical table and the scale units determine. It practically represents the amounts of each of the eight elements in the year 1908 as indicated by the line drawn horizontally across the chart, for the increase or decrease is "over" that year or line. In other words, the movement of the

curves for any one and all of the six years in relation to the zero line is determined by the relation of the amount in each year to the amount in 1908. Thus the fluctuations in the curves from year to year should be read or measured from this zero line and not from the slopes of the curves themselves.

Facility in the interpretation of such a chart is aided if it is clearly indicated that all the movements of the curves above the zero line mean increases over the base year and below that line decreases compared with that year. This is accomplished by inserting the words "Increase" and "Decrease" alongside the vertical scale lines on either side of the zero line. This shows clearly that the vertical scale reads upward from the zero line for increases and downward for decreases.

Assistance in the clear interpretation of such a chart is also rendered by making the zero line slightly heavier or wider than the other horizontal lines connecting at other units of the vertical scale lines and at the same time not as heavy or as wide as the curve or curves themselves. This wider zero line calls the reader's attention to the fact that he must interpret the movements of the curves from the zero and not from the lowest or base line.

In cases where the figures to be charted show

no decreases and in consequence it is not necessary to extend the curves below the zero line, then this line becomes also the lowest or base line at the bottom of the chart and all the movements of the curves are above that line. In such cases it is not necessary to employ the terms "Increase" and "Decrease" above and below the zero line. Nor is it necessary in such cases that the zero line be made wider than the other horizontal lines.

While the chart on page 124 designates with a cipher the horizontal line from which the movements of the curves are measured, as a matter of fact this line is not a zero line but a 100 per cent line. This is true arithmetically for the reason that in reality it represents the total amount of each element or item for 1908. These were taken as the base from which the figures for each of the other years were ascertained. Arithmetic exactness requires that this line be designated as a 100 and not a 0 line. But in this case chartography takes liberties with arithmetic for the sake of securing greater clearness in interpretation. Experience has taught that because of the general lack of knowledge on the part of many of those for whom charts are prepared, confusion leading to misinterpretation, and this to misinformation, results whenever the 100 per cent designation is employed in place of the cipher.

THE ARITHMETIC AVERAGE

In the chart on page 124 the basis upon which the respective percentages have been computed is, as has been said, an amount for a single year. Wherever possible this basis should be the average of the amounts for a number of years, and this is nearly always feasible when the number of years in the table comprises ten or more. This average is ascertained by adding the amounts for the years selected and dividing the total thus obtained by the number of these years. The percentage increase or decrease is then computed for each of the years from this average amount. This is not advisable for the statistics in the chart on page 124, as the number of years is only six. In those cases where it can be done there will likely be found a material difference between the movements of curves over a period of years thus disclosed compared with the movements shown with only a single year as the base.

The advantage of taking the average for a number of years as the base for computing increases or decreases is found in the fact that this average smooths out the irregularities of high and low or of large and small amounts which may have been comprised in the different years. If a single year only is used as the base it may be that in that particular year unusual influences or

forces were at work to change unduly its total in comparison with preceding or following years and in consequence it is out of normal relation to the amounts of the other years.

An illustration of this as to many phases of railway operation, for instance, is the fiscal year 1908 extending from July 1, 1907, to June 30, 1908, both inclusive. The records for that fiscal year include the effects of the panic in the latter part of the calendar year 1907. The railroads were very seriously affected by this disturbance in business and financial conditions and their traffic and revenue fell off strikingly. In consequence, any comparison of the operations and finances of subsequent years based upon the single year 1908 would show tendencies that might not and would not be shown if a year that did not record a panic was used as the base. Averaging a number of years escapes this possibility of statistical error and in consequence avoids misrepresentation in chartography.

The proper use of the average is an important asset to the chartographer. This average repersents or indicates the usual or common occurrence or status. It is, primarily, as has been stated, a problem of arithmetic. Quite often, if not always, it is simply an arithmetical standard, non-existent in actual reality and yet one around which other

facts tend to approximate or conform and by which they are measured or compared. Such, for instance, as the average height of men, or the average price of a pound of bacon, and so on.

THE MISUSE OF THE AVERAGE

The average can be as much of a sinner when improperly made use of as it is a saint when properly employed. To the chartographer the use of the average has its pitfalls against which he must be constantly on his guard. While it is indispensable at times, it has its limitations and shortcomings and these must be known if he is to make the best use of it and not be inveigled by its attractions into grievous errors.

Quite frequently the average comprises elements radically different from each other whose irregularities or dissimilarities have disappeared or been smoothed out to such an extent that it does not represent any measurable status or even approximate situation of the actual facts, and in consequence can have no other effect than to mislead. This is illustrated, for instance, in statistics giving the average amount of stock held per stockholder in the railways of the United States.

In 1914 this average was stated as $13,958. It was obtained by dividing the total number of stockholders—622,284—into the total par value

capital stock outstanding—$8,685,764,000. Of course, such an average is absolutely meaningless. It is merely an arithmetic average. No such amount of stock approaches even in the slightest degree to the actual facts in the case. The fallacy in any practical use of this average can be demonstrated by a simple illustration from almost any railroad.

Let us take the Wabash for an example. In 1915 a single stockholder—the Equitable Trust Company—owned $28,744,000 of the stock of this railroad. With nine others, these ten largest stockholders together held $59,449,200 of the stock, or more than sixty-four per cent—nearly two-thirds. In view of these very large single holdings of stock by a very small number of stockholders—these ten owning by themselves an average of $5,944,920—any arithmetical computation representing the average amount held by each stockholder cannot fairly represent the situation as to the ownership of stock in the Wabash Railroad Company.

THE STATISTICAL CLASS LIMITS

In such cases as this instead of making use of a meaningless average there is the possibility of recourse to a separation of a group of figures into class limits in order that the facts of a given situa-

tion may be more accurately presented. This should always be taken advantage of whenever possible.

Applied to the preceding illustration it simply means the separation of the total number of stockholders into groups or classes according to selected amounts of stock held. The first step in this statistical process is to determine upon the limitations for the different classes. These are purely arbitrary. To obtain them, round numbers are most desirable, as these give clear cut groups. These numerals form what are technically known as boundary lines of the classes.

The difference between them is called statistically the class interval. These class intervals should all be equal or uniform.

The number of classes and the number in each class become statistically what is called a frequency table.

By thus dissecting the statistics a number of very interesting and highly important facts is usually disclosed which the presentation of the average does not indicate as being present. A knowledge of these facts is essential to a correct and complete presentation of the actual situation.

These facts indicate that the chartographer must exercise his best judgment in the presentation of the average. He cannot be permitted

to excuse himself by hiding behind statistics. Charts that reflect inaccuracies and irregularities of mathematical computation to the extent of being misleading cannot be explained away because, in truth, they never should have been made. This is a high standard to attain, for quite often the chartographer must depend almost entirely upon his statistics for a truthful presentation of the facts, and if the statistics are faulty it seems rather unfair to hold the chartographer to strict responsibility for any misleading result. Nevertheless, the chartographer should be as scrupulous and as exacting in the use of statistics as in the use of the English language in maintaining a high standard for truthfulness and exactness.

A sufficient variety of curve and bar charts have been presented in the preceding Lessons to impress upon the student of chartography that his most important task is the planning of the chart. It should be done before he touches pen to paper in beginning the drawing of the chart. With this planning successfully accomplished the remaining details of the work of execution or construction becomes a relatively simple matter.

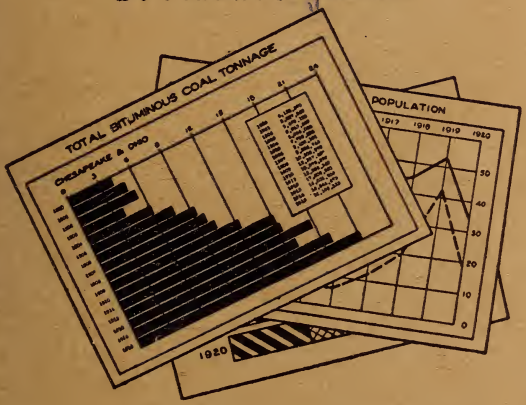
In this planning the student should first know thoroughly the real meaning or significance of the table of statistics he is to chart—he must "see" clearly the vital point of comparison the

chart is to bring out. It is of advantage in comprehending this point if the student will roughly sketch several different charts, both curve and bar, before he attempts to lay out the curve or bar in ink. He will be surprised at the difference in results shown by the various methods, and can then select the one which best illustrates the significance of the statistics. More time relatively should be given to the planning than to the actual drawing of the chart. The time devoted to the latter will be greatly shortened if the planning has been done correctly. Besides, it will also save time lost through changes and alterations usually made necessary where the planning has been neglected.

QUESTIONS FOR SELF-EXAMINATION

1. What is the value of statistics to chartography?
2. What is the statistical table? How should it be arranged?
3. Describe some of the technical aids to the interpretation of a table of statistics.
4. What are ratios? How are they computed? How arranged in table form?
5. Describe the construction of a statistical table.
6. What are the important differences between ratios and percentage increases or decreases?
7. Of what value to the chartographer are percentage increases or decreases?
8. Describe the zero line and its use in charts showing percentage increases or decreases.
9. What is the average? How is it computed? Describe its advantages and disadvantages.
10. What are statistical class limits? What are boundary lines of the classes? What is the class interval? A frequency table?

CHARTOGRAPHY
IN TEN LESSONS
BY FRANK J. WARNE



LESSON X

PRINCIPLES OF CHARTOGRAPHY

PUBLISHED BY
FRANK J. WARNE
SOUTHERN BUILDING
WASHINGTON, D. C.

LESSON X

Primary Principles of Chartography

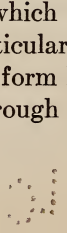
Planning the Chart—Importance of the Right Method—Essentials of Good Chart Making—Planning the Size of the Chart—Planning a Reduction in Size—The Reducing Glass—The French Curves—Checking up the Chart.

Chart-making for commercial and other purposes is still in its infancy and in consequence has not yet been systematized. Statisticians who are employing it to an increasing extent as an aid in the presentation of facts are in disagreement, or rather are not in accord, as to the superiority of different methods. Give a group of statisticians who are also familiar with chartography a set of figures to chart and there will likely be as many different kinds of charts widely divergent in methods as there are statisticians. Thus the same information will be charted in many different ways. While variety in charting is possible where numerous illustrations must be made, at the same time some methods are better than others in bringing out the facts more clearly. Variety of effect is permissible and sometimes desirable in order to avoid monotony in presentation and to retain attention.

A CHOICE OF METHODS

The value of the chart method being in expressing clearly the meaning of a statistical table, the problem of the chartographer is to select the one method from among the many that will best express this meaning. Particularly is this true in the use of charts by the large corporation. Prepared usually for the executive whose time is limited and of great value, the chart must be so drawn as to give to him instantly the true significance of a mass of statistics which he has not the time to analyze in their details. The efficient and successful executive must decide quickly and of course correctly. The information furnished him on the chart must not only possess an accurate background but it must also be presented to the best advantage if he is to make the right decision and avoid "guess work." The busy executive is more and more being compelled to place greater dependence upon the chart analysis of statistics.

As has been made clear, in the practice of chartography there is a choice of widely varying methods. No general rule can be given for determining which of these methods is the best for any particular purpose, but practice will enable one to form his own judgment as to selection, and through experience he will learn to



choose the method best adapted to each of the varying problems.

Importance of the right method

The importance of selecting the best method is emphasized by Brinton in his *Graphic Methods for Presenting Facts.* He says: "After a person has collected data and studied a proposition with great care so that his own mind is made up as to the best solution for the problem, he is apt to feel that his work is about completed. Usually, however, when his own mind is made up, his task is only half done. The larger and more difficult part of the work is to convince the minds of others that the proposed solution is the best one—that all the recommendations are really necessary. Time after time it happens that some ignorant or presumptuous member of a committee or a board of directors will upset the carefully thought out plan of a man who knows the facts, simply because the man with the facts cannot present his facts readily enough to overcome the opposition. It is often with impotent exasperation that a person having the knowledge sees some fallacious conclusion accepted, or some wrong policy adopted, just because known facts cannot be marshalled and presented in such a manner as to be effective.

"Millions of dollars yearly are spent in the collection of data, with the fond expectation that the data will automatically cause the correction of the conditions studied. Though accurate data and real facts are valuable, when it comes to getting results the manner of presentation is ordinarily more important than the facts themselves. The foundation of an edifice is of vast importance. Still, it is not the foundation but the structure built upon the foundation which gives the result for which the whole work was planned. As the cathedral is to its foundation so is an effective presentation of facts to the data."

ESSENTIALS OF GOOD CHART-MAKING

The primary essentials of good chart-making are simplicity and clearness. The curves or bars of a chart are employed to express and to communicate ideas, just as words are used in the English language. The fewer the ideas it is attempted to express in a single chart, the better. In fact, a single chart should aim to express only a single idea. This is difficult to accomplish, as the essence of a chart is a relation or a comparison and this usually involves more than one idea. The aim, however, should be to construct the chart so that all but the dominant idea it is intended to express or communicate is kept

subordinate or in the background. There should not be a single unnecessary mark or figure or word on the completed chart, and if its full meaning cannot be grasped quickly, then it has failed of its object.

There is a common and quite general violation of these principles. Chart-making is not at all complex; it does not involve a knowledge of higher mathematics for correct presentation and interpretation. There are a few definite rules which, if once understood, result in the ease and facility that may be likened to a knowledge of the alphabet, once acquired. Much of bad chart-making and of confusion in interpretation flows from a violation of the few simple principles.

Planning the Size of the Chart

One task that will likely confront the student with as many perplexities as any other will be the working out of the size of the chart within the limitations of the sheet and the requirements of the statistics. Only practice will enable him in time to overcome most of these difficulties. But as a sort of guide for meeting some of these problems there is presented in the following paragraph a practical illustration.

The size of the sheet for the completed chart is arbitrarily fixed for us at 12 by 16 inches. At

least two of the 16 inches are required as a margin on the left of the sheet (the chart appearing lengthwise) for binding. Usually an inch margin on the remaining three edges is advisable. This leaves 13 of the original 16 and 10 of the original 12 inches as the size within which the chartographer is to work, or a size 10 by 13 inches. The neat lines of the frame and the letters of the title must come within this size. Usually one-half inch is sufficient for the title letters, and in our particular illustration it is required that the title appear lengthwise of the sheet. This reduces the size to 9.5 by 13 inches. Between each of the neat lines and each of the scale lines one-half inch will usually be sufficient—this is a reduction in both dimensions of another inch. Sometimes a full inch is required below the lower horizontal line for the footnotes. Of course these spacings are subject to being increased or decreased according to the requirements of varying problems. The original size of 12 by 16 inches has dwindled by the above mentioned processes to 8.5 by 12 inches as the size of the framework proper.

The arbitrary limitations of space within which the chartographer is confined in his work cannot be removed from among the difficulties of the practice of the art. All that he can do is to learn by experience to make the best adjustment pos-

sible in each particular problem. This is true no matter what the size is that is determined upon. And having made the decision the chartographer will soon learn to adapt himself to the limitations of space and to forego something that is desirable in order to adjust his work to the exigencies of the requirements.

In most cases where a number and variety of charts are to be filed for reference or bound as exhibits it is quite important that the size for all the sheets be made uniform. This does not necessarily mean that the worker will have the same size for the original of all the charts themselves, but it does mean that the completed charts shall all be on sheets of the same size. This permits of uniformity in size for all completed charts and assists in securing neatness and orderliness in office records. Completed charts on sheets of different sizes are awkward in handling and easily damaged.

PLANNING A REDUCTION IN SIZE

Where the original drawing is to be reproduced by one of the several photographic processes and printed from plates, the chartographer has a special problem of reduction in size to solve. In such cases the pen-and-ink chart should always be considerably larger than the final reproduction. Most charts will stand a reduction in size of from

one-third to one-half and in cases even more, and will be improved in appearance by the process. A reduction in the size of the original drawing tends to smooth out the rough places or minor irregularities of lines, curves, bars, figures, and letters and results in a much cleaner effect. Virtually all the charts in these lessons have been reduced approximately one-half from the size of their original drawings.

In ascertaining the dimensions for the size of the original drawing simply apply the rules of proportion. Only four factors are involved—the width and length of the reproduced chart and the width and length of the size that must be drawn to secure the reproduced size. Assuming our problem to be the one mentioned on page 142, we know the width and length of the reproduced size—the former is 10 inches and the latter 13 inches. We know also how much of a reduction we desire to secure—whether one-third or one-half and so on. Selecting a reduction of one-third gives us the arbitrary width of the original as 15 inches. It is the length of the original that must next be learned.

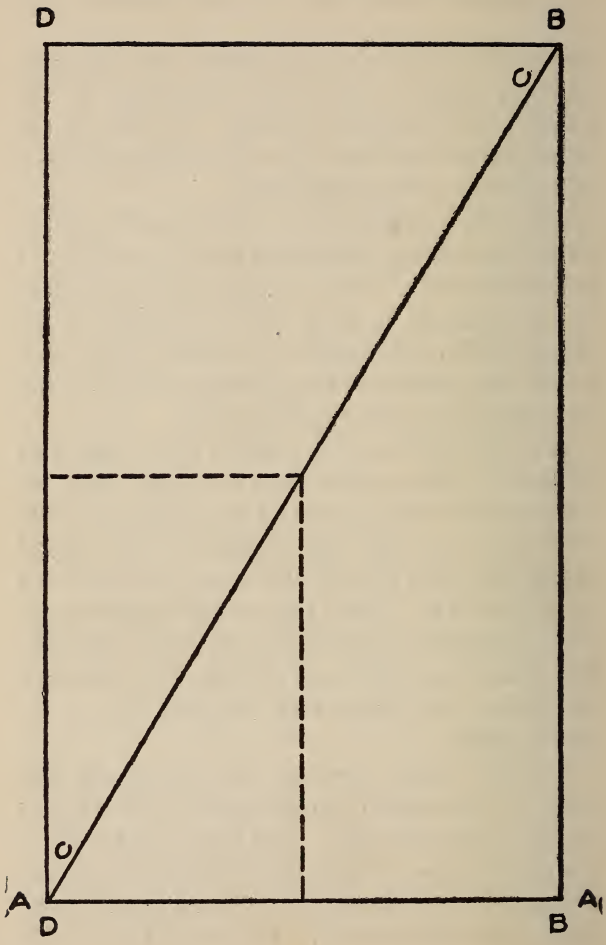
Our known figures give us this formula: 10 : 13 :: 15 : x, which reads 10 is to 13 as is 15 to x. Working out this formula we learn that 13 times 15 equals 195 and this number divided by 10 gives

19.5. This latter thus represents our unknown fourth quantity, which is the dimension of the length of the original drawing. The size of the original must then be 15 by 19.5 inches to secure a reduced size of 10 by 13 inches.

In the above illustration the number 10 and the letter x are known as extremes and the numbers 13 and 15 as means. In any proportion the product of the extremes is equal to the product of the means, that is, 10 times x, the latter being 19.5, is 195, the product of the extremes, and 13 times 15 is 195, the product of the means.

It is also true that the product of the extremes divided by either mean gives the other mean, as for instance: The product of the extremes is 195 (10 times 19.5) and 195 divided by 13, one of the means, gives 15, the other mean, or 195 divided by 15 gives 13. Again, the product of the means divided by either extreme gives the other extreme. For illustration: 13 times 15 is 195, the product of the means, and divided by 10 gives 19.5, or by 19.5 gives 10.

Another simple method for ascertaining the reduced dimensions from the original is illustrated on the following page. The larger rectangle is our original size. From its lower left hand corner a diagonal line is drawn in light lead pencil to the upper right-hand corner. This is line C-C. This


D
B
C
C
A
D
B
A1

diagonal line is then connected by a vertical line starting at any point on the base line A-A, such as the broken line shown. From the junction point of the broken line and the diagonal line draw another broken line at right angles to the vertical line and extending to line D-D. The rectangle thus circumscribed in the lower left hand corner will be found to be in exact proportion to the larger rectangle, or the size of the original.

In planning a reduction in the size of the chart from the original, care should be exercised in seeing that all the lines on the original are made sufficiently wide to stand the reduction in line width due to the decrease in size. In our preceding illustration on page 144 the lines would be only one-third as wide in the completed as in the original drawing. Therefore, all the lines and curves and so on of the original must be made wider than would be necessary if the chart were not to be reduced. Failure to allow for this reduction in the width of the lines and curves and letters and figures is a common mistake made by the beginner in chartography which should be guarded against if the best results are to be secured.

THE REDUCING GLASS

A valuable aid in this branch of the work is the reducing glass. It may be said to be the opposite

of the magnifying glass, decreasing instead of increasing the size of the object observed, the lens being ground concave instead of convex. A convenient size is one with a single lens about one and three-fourths inches in diameter. This permits the lines, figures, and letters on a chart to be seen in sizes from one-half to one-fourth smaller than their originals.

In observing the parts of the chart for an indication of the size of the proposed reduction the most accurate method is to hold the glass at different distances above the sheet so that looking through it with the left eye two or three or four squares, depending upon the amount of reduction desired, equals one square as seen by the unobstructed right eye. Thus by superimposing and comparing the images of both eyes the required reduction can be measured. This enables a comparison of the width of lines, figures, and letters as originally placed with their width after reduction and permits the determination as to whether they must be made still wider or heavier or larger in order to meet the reduced size. Even with the use of the reducing glass the beginner is likely to find at first that his lines, curves, figures, letters, and so on when reproduced do not appear to be as heavy or as large as he had anticipated.

Without the employment of these rules and aids in reduction one has to depend largely upon guess work as to whether the chart and its parts will present a proper appearance when reduced, and guess work, as has been said, should be eliminated from chartography. The student must not forget that accuracy is a valuable mental quality which is useful elsewhere than in chartography, and if the practice of this art teaches it to him he has gained an additional asset of great usefulness.

THE FRENCH CURVES

Another tool that the student may find useful, especially in charting curves, is what is known as the "French curves." These are on sale at any first-class store dealing in drafting instruments. While they do not always in their entirety fit into the complete curve the student has to make, they can be shifted forward or backward so as to cover fairly accurately the lead-pencil dots measuring the points of contact of the curve. Usually they give a clean, smooth curve if care is exercised in their use.

In most charts where the scale units permit the curve to move regularly up or down across the sheet, the curve appears smooth without sharp movements that result in peaks. In all the

illustrations in these Lessons these curves have been drawn in freehand, and this method is recommended as satisfactory. This peak-top does not indicate as minute a degree of accuracy in the figures upon which the curve is based as does the smooth curve.

OTHER MECHANICAL AIDS

One serious drawback in making the letters by hand is the length of time required, even after one becomes proficient in lettering. Under conditions where the number of charts to be drawn is large, efficiency is best served and the cost of production materially reduced if recourse is had to a small printing press with about three fonts of type of 18, 12, and 10 point, commercial Gothic. The moderate expenditure will soon be compensated by using for other work the time saved from lettering by hand. Printed letters photograph satisfactorily in almost any process of reproduction.

Another recourse instead of drawing letters by hand is to make use of gummed black paper letters and figures which are for sale at first-class stationery stores. These can usually be pasted quite neatly on the chart that is to be reproduced, if a light pencil line is made for a guide along the bottom of the spacing for the

letters. This pencil line must of course afterwards be erased.

Checking-up the completed chart

After the drawing has been finished there remains for the student a very important task. The explanation of this task in detail involves describing the concrete application of all the rules and principles of chartography that have been observed in the construction of the chart. This is true in the sense that the student must see to it, by a rigid and thorough checking-up of the lines and figures and letters and so on before the chart leaves his hands, that all these rules have been strictly applied. As related to the checking up of certain features of the curve chart, this task has already been referred to in Lesson IV, pages 50 and 51. The immediately following statements apply particularly to the bar chart.

Each bar should extend to the point on the chart that its statistical number as measured by the scale determines—it should neither fall short of this point nor extend beyond it.

Be sure that each bar is properly spaced from adjoining bars.

In making the bars of a chart it is quite often possible that all the space to the right of the vertical scale or column of years and to the left of

the ends of the bars, and from the horizontal scale line to the base line, can be made black with a small brush dipped in India ink, the ends of the bars being squared with the pen. After the ink dries the bars can easily be outlined and separated from each other according to the vertical scale units by drawing horizontal lines in Chinese white. This expedient enables a great deal of work to be done in a comparatively short space of time, and the results are highly satisfactory. When the India ink is used in this way it is advisable to apply two or more coats or washes in order to insure a uniform density of surface.

Chinese white is an opaque composition which may be thinned down to desired consistency by the addition of water. Besides its use in separating bars out of a block of black, Chinese white is also excellent for concealing black ink lines or marks where erasure is impracticable.

The scale units should be correct at each of the points of measurement and neither to the right nor left of their proper places.

The chart should include the statistical table from which it has been made.

If it is found impossible to include the statistical table on the chart it should be on an accompanying or attached slip or sheet.

The table of figures should be correct and neat and properly located and boxed without crowding.

The period of time column both in the table and adjacent to the bars must be correctly and properly alligned.

Be sure that no mistake has been made in copying any figures on to the chart.

The statistical table involving periods of time should be presented with the earliest period first.

The source of the statistical table should in every instance be given, preferably in the footnotes.

Instead of checking up the movement of the bars or curves from either the statistical table on the chart or the scale figures themselves, reference should be had to the original figures.

All additions, subtractions, multiplications, divisions, and so on derived from the statistical table should be computed at least twice and by different persons.

See that all horizontal lettering reads from left to right and all vertical lettering from the base of the chart upward.

The title should be clear and concise and yet comprehensive. It should have every word spelled correctly and should contain the fewest possible words consistent with clearness of expression. It sometimes happens that the title

can be improved in these directions over the first selection of words after the student has been working with the statistical material. Words as well as letters in the title should be evenly placed and spaced—none of them must be askew.

THE PROCEDURE IN CHECKING UP

It is an advantage in checking up a chart to start with the title, next the horizontal scale, then the vertical scale, the table of statistics, and then relate the movement of the curves or bars to these factors. The horizontal and vertical lines forming the background of the chart must not be overlooked as to their proper distance apart. The foot-notes and the neat lines require equally careful attention.

Make sure that the neat lines are wider or heavier than the vertical and horizontal lines of the framework.

Foot-notes should be as brief as possible consistent with clearness, should read from left to right, and should not be askew.

In selecting the designations for the curves and bars, have the most conspicuous been made to correspond with the particular statistical element it is desired to emphasize? For instance, in bar designations the solid black is generally more noticeable.

Check carefully the key or legend designations with those of the curves and bars to see that they correspond accurately.

Have the proportions been correctly determined for the required reduction?

Be especially careful that all lead pencil and unnecessary ink marks, used as guides or otherwise, have been erased or removed. If not, in case of reproduction these are likely to photograph and thus affect disadvantageously the neat appearance of the chart.

CLEANLINESS ESSENTIAL TO NEATNESS

In handling a chart keep the hands clean, especially from the drawing ink which will smear the sheet. An aid to this will be found by keeping the ink bottle on a blotter which will absorb drops and prevent them from getting on the drawing board or table. Blot immediately every ink spot.

Never fold a chart. Keep the sheet flat or roll it. A folded chart cracks or creases the sheet and breaks the lines, bars, curves, and so on.

All checking and verification should be done also by some one other than the person who drew the chart so that there may be greater certainty in the detection and correction of errors. For even the best chartographer makes mistakes.

The student should assure himself before per-

mitting the chart to leave his hands as completed that in all respects it is in condition to receive his final O. K.

PLOTTING THE CHART IN ROUGH OUTLINE

After the chartographer has completed his checking up he should devote several minutes to a consideration of the possibility that he might have selected a different method which would have brought out the point of the statistics more clearly. He will have fewer regrets if he adopts and consistently follows the practice of first plotting his chart in rough outline in lead pencil at the very outset of his work. He should apply this to several methods before finally determining upon any. He will find that though this practice takes a little time at first it will in the end greatly expedite his work.

It should never be forgotten that as chartography primarily supplements statistics with the object of making them clear and comprehensible at a glance, a chart that is not more clear in exposition than the statistical data upon which it is based has missed its object. Also it should be remembered that the chart "tells the story"—it should need very little explanation, if any.

Instructions to the lithographer should be clear and definite. These may be written on a slip of

paper and attached to the drawing with a clip, but a safer plan is to write them on the coordinate sheet itself, preferably on the back.

Before sending the drawing to be reproduced be sure to cut away the margin of the sheet where the thumb tacks have held it in place on the drawing board, as these punctures are likely to show in the reproduced chart. Even when the drawing is not to be photographed, such punctures in the paper detract from the neat appearance of the finished chart.

Before deciding upon the uniform size of sheet for a number of different kinds of charts it is advisable to consult the lithographer in order that a size may be selected which permits of the least possible waste or loss in cutting from the larger sheet.

It is important also to examine closely into the quality of the paper of the reproduced chart. The preservation of the chart depends to a large degree upon this quality. Paper containing sulphite pulp or other chemicals suffers rapid deterioration. Within a short time such paper becomes brittle and discolored, and these defects seriously affect the preservation of chart records for any length of time. A high grade linen bond paper, although it costs more per sheet, is less expensive in the long run.

The checking up of the completed chart as well

as the details of the planning and drawing should impress upon the student the necessity for observing closely and carefully every factor with which he deals. He cannot afford to overlook even the smallest detail as every detail must be accurate if the completed chart is to be accurate. This attention to minor details fixes the mind upon the correctness of the figures; on the accuracy of the scale units; on the spacing of figures and lines; on the spelling of words; on the correct designation and spacing and length of the bars, and so on. Looking for possible defects or errors develops the critical faculties. In the course of practice all these separate but important details soon fix a habit of mind and that which at first may be hard work sooner or later becomes almost mechanical attention. Working with tools that require accuracy in their use the chartographer soon learns from mistakes he must correct that it does not pay to make mistakes—that it is a loss of time and energy and materials—and he comes consciously to apply himself so as to avoid their repetition in order not to be compelled to do the work over again. Out of this experience he learns efficiency in the concentration of his energies and in their application to his specific task. Chartography is thus an invaluable mental training. It lends accuracy to

constructive thinking; it leads to the further study of statistics and of the underlying forces back of them, and by these and similar steps the progressive student develops his thinking capabilities.

QUESTIONS FOR SELF-EXAMINATION

1. What is meant by planning the chart? How does it differ from plotting the chart?
2. Discuss the importance of selecting the right method.
3. What are the essentials of good chartography?
4. How is the size of the chart planned?
5. How is a reduction in size of the original determined?
6. Of what assistance is the reducing glass?
7. What are "French curves"?
8. Describe the more important phases of checking up the completed chart.
9. Summarize briefly the more important of the fundamental principles of chartography.
10. Of what value is chartography in training the mind?

Rimmer p. 64