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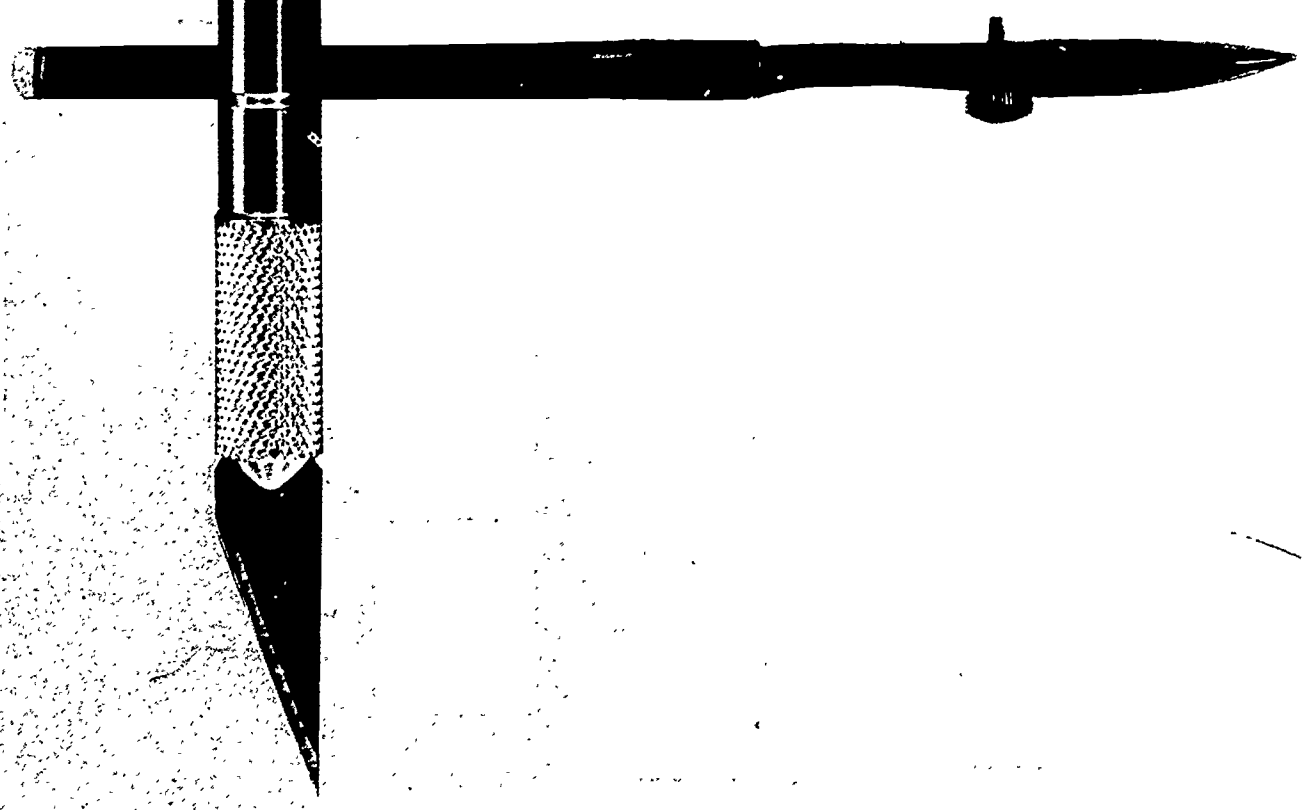
This booklet on graphical techniques of communications in science was written to aid the student who might be engaged in a project in which a quality report will be required. Written for the secondary school student, it concentrates on the graphic presentation of data, indicating the planning and techniques involved as well as the supplies and instruments that are generally used. Topics include (1) nature of graphic presentations, (2) choosing a graphic form, (3) the professional touch, (4) tools of the trade, (5) charts, and (6) maps. Section II deals with tools and specific techniques. A bibliography is included. (DH)

GRAPHIC COMMUNICATION IN SCIENCE

A Guide to Format, Techniques, and Tools

Nelson P. Guidry
and
Kenneth B. Frye



National Science Teachers Association • A Department of the National Education Association • Washington, D. C.

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FOREWORD

GRAPHIC COMMUNICATION IN SCIENCE

In almost every occupation today we find ourselves communicating information through pictures, diagrams, charts, and tables. Much of this information is in the form of data which we want to communicate accurately and vividly, whether we be professional worker or student.

The original idea for this publication was inspired by the needs of the thousands of students in the nation's secondary schools who undertake the scientific activity of planning, conducting, and reporting independent research-type investigations.

Many of these student reports go no farther than submission for class or perhaps extracurricular credit. Others, however, are presented as entries in awards programs. In science, this may be in the NSTA Future Scientists of America Awards Program or for programs of many other agencies, such as the Westinghouse Talent Search and the congresses and meetings of the junior academies of science. Such papers mark the student's entry into the professional activity of report writing, and on the quality of the report may depend a major scholarship award or significant honor. Even those reports that remain with the student or teacher may be the first steps in one of many vocations, or may be an ancillary skill in almost any future profession. Therefore, reports represent work that should be learned correctly from the first attempts.

For the most part this book concentrates on the graphic presentation of data—planning and techniques to be used as well as the supplies and methods that make the work easier and more attractive. It introduces the reader to concepts of communication through graphic presentation and to many of the tools that the beginner and the amateur can "borrow" from the repertoire of the professional.

This emphasis on the graphic presentation of data is not intended to lessen the importance of a well-planned and carefully designed study. Without such a study the data and their presentation become not only empty, technical exercises but also misleading in the conclusions that may be drawn from the data. Several excellent publications are already available to aid in the planning of research studies. Some of these are listed in the Bibliography.

The National Science Teachers Association is deeply indebted to the two authors for their generosity in sharing their knowledge and techniques —both of the highest professional quality—with students and teachers and others who wish to communicate statistical and scientific data effectively.

Robert H. Carleton
Executive Secretary
National Science Teachers Association

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1 GRAPHIC PRESENTATION

by
Nelson P. Guidry
Instructor, USDA Graduate School and
Geographer, Foreign Regional Analysis Division
Economic Research Service
U.S. Department of Agriculture

WHAT IS GRAPHIC PRESENTATION?

Graphic presentation is in effect the art of presenting data or facts in the form of an illustration. An illustration, as far as graphics is concerned, can be either a chart, a map, a diagram, a photograph, or a combination of any of these. (See Figure 1.)

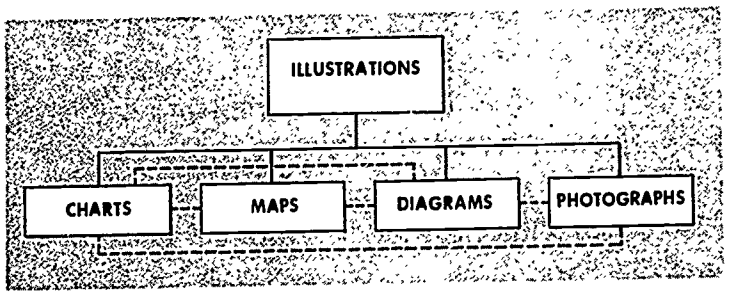


FIGURE 1

CHOOSING A GRAPHIC FORM

Selecting the best graphic form or forms for your project should be attempted only after a careful analysis of the data. You should not only be familiar with the major groups of illustrations but also understand their functions. The following points may aid you in arriving at a decision.

1. Function

Do you fully understand the function of your illustration? Think of your selection from the reader's point of view. Whatever your final choices may be, they have to be crystal clear, self-explanatory, or at least fully and clearly explained in the text. Remember—you will not be along to explain them.

2. Emphasis

Emphasis on the wrong points can weaken an otherwise good research project. Pick out the salient points and try to illustrate these to the best advantage. Trends, parts of a total, percentage changes, absolute values, differences, etc., are all points that could be considered for illustration.

3. Analysis of data

Do you have enough data? Are you satisfied with the quality? Will additional statistical calculations be necessary to refine the data? Are there just a few, or an unusually large number of observations? Have you too many time periods or items to plot? Will they all fit within a reasonable scale, or should you select, combine, or eliminate some of them?

4. Preliminary choice of format

Make rough-sketch experimental layouts in different forms. The rough freehand layouts should omit fine detail, and the plottings can be rounded and rough. But all parts should be in their approximate places. Compare the rough charts for effectiveness. Try the layouts out on yourself. Ask yourself questions, and try to find the answers

on the charts. This important preliminary work will save you many hours of work that might otherwise be wasted in drawing the wrong illustration.

5. Cost

Illustrations can be expensive to construct, even more so when your choice requires expensive equipment. Do you have too many similar charts when perhaps, fewer, better chosen, more significant illustrations would suffice? Make sure your selection is worthwhile.

6. Time

Illustrations can be time consuming. Do not leave them until the last minute. A good selection can be ruined by last-minute sloppy work. If the deadline is a factor, it is sometimes possible to use a more simplified layout. Study the construction problems to see whether you could apply short cuts. Make scales in larger units such as thousands or millions to cut down on the number of zeros, etc., or use scientific notation. Why spend time outlining bars of a bar chart when colored strips of Zipatone cut to the proper width will form neat-looking bars? If data are subject to last-minute revisions, alterations can easily be made by cutting off the bars or even changing the bar entirely. Use tapes or cut strips of Zipatone for curves; these are also easy to revise.

7. Source

Do not copy a chart or technique just because you have seen it in print. Check other reliable sources to see whether it is in line with accepted practices. Poor practices as well as errors have been copied repeatedly all too many times.

Analyze your selection. Check for significant points pertaining to your study. Watch for trends or for projections that could be made from the trends. Watch for repetitive cycles or fluctuations short or long, or the lack of them. Be critical; look for points that need strengthening or seem out of line. If some plotted points seem completely out of line, recheck the data and the plotting before drawing a conclusion. Example—long-time averages of monthly temperatures plot as a relatively smooth curve. If one point is out of line with this trend, the plotting or the data could be wrong; look for other sources. Have someone else check and recheck data as well as plottings. Sometimes a good chart can bring out important salient points that were overlooked in the project—a trend, repetitive cycle, differences, etc. Be factual, try to draw logical conclusions from the presentation, test them on others.

THE PROFESSIONAL TOUCH

Illustrations can be neat and professional-looking even in rough form. To help you achieve the professional touch, we have borrowed certain techniques from the repertoire of the professionals. For more about techniques and tools, see also Section II.

1. Width of lines

The width of certain lines can be varied to aid legibility and to distinguish one from the other. The grid lines should be considered to be in the background; they are used to plot the curve or bars and help the reader interpret the chart. Therefore, the grid lines should not interfere with the rest of the chart and should be the lightest lines on the chart. The base line or prime reference lines should be accented by being made heavier than the other grid lines—generally about twice as heavy. The most important lines on a chart are the curves. They should also be the heaviest lines, generally about twice as heavy as the base line. The lines, thus separated, are distinct and cannot be mistaken for each other.

2. Lettering

Perhaps one of the greatest faults by the amateur chart maker is poor lettering and poor legibility. Lettering is one of the most important parts of the illustration. It is placed there to identify the various components. Without it the illustration would be meaningless. Therefore, lettering must be of a size, style, and boldness that will be legible on the final presentation.

Lettering is so important that it must have the right-of-way over all other chart components. Never draw grid or other lines through your lettering. Stop them a short distance from the lettering.

Follow this rule to insure good legibility on charts; make the smallest lettering, such as that used for a note, not less than 6 points[1] in height. If the chart has to be reduced photographically—to, say, 50%—then the smallest lettering should be doubled, 12 points, on the original before reduction.

The title should be the largest and boldest lettering of all, but should be in balance and kept in proportion to the size of the chart.

The height, style, and boldness of the lettering used on a chart can be further varied by using, for example, all caps (all capital letters) for one component, or caps and lowers (capitals and lower case letters) for another. Still other variations can be had by using slant as well as vertical lettering. The choice is up to you, but be consistent. Make the lettering for each component the same on all similar charts. Example—The scale numbers on the vertical and horizontal scale on one chart should be made the same height, style, boldness, etc., as the scale numbers on another similar chart of the same size. The same is true for the other components.

This technique helps one to distinguish between the different components, separates them, and makes the chart easier to follow. Choose a style of lettering that is easy to read, easy to construct, and also reproduces well if this is a factor.

3. Shadings

The technique most often used for shading areas on an illustration is called crosshatching. Crosshatching is a network of lines and/or dots designed to produce distinct patterns as well as to simulate different gray tones. Printed patterns on thin plastic sheets with an adhesive on the back are available from art supply stores under brand names of Zipatone, Craftint, Artype, and others.

[1] Points and picas are printer's measures; 6 points are approximately 1/12 inch.

Although not distinguished as such in commercially printed patterns, there are two major groups of crosshatch patterns—area and density.

- *Area patterns*—Any appropriate pattern may be used as an area pattern. These patterns are used on maps and charts to distinguish one area or one part from another by pattern design alone. Sometimes separate colors may be used as a substitute for area patterns. The chart or map designer needs only to select separate, distinct, clear patterns or pleasing colors that will produce a nice-looking, neat presentation. Whether colors or patterns are used, the areas should be clearly labeled either directly or in a neat legend. (See page 27 for the construction of a map legend.)
- *Density patterns*—Density patterns (See Figure 2.) are patterns that show a distinct uniform gradation in tone from black through white. They are used on maps to represent statistical values. It is an accepted practice to let the lighter tones represent the lower values, the darker tones the higher values. Density patterns may also be used as area patterns, but not all area patterns may be used as density patterns. Density patterns usually have to be selected from the available array of area patterns. Separate colors cannot be used as an effective substitute for density patterns. However, density patterns printed or drawn all in the same color will be just as effective as those printed in all black. Illustrations that should use a density range of patterns include pie charts, composite bars, strata charts, all isoline maps, and crosshatched maps showing values.

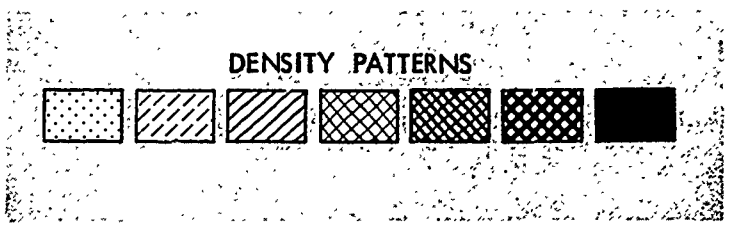


FIGURE 2

When selecting patterns, it is important to consider not only the weight of lines and dots, but also the distance between them. The patterns

selected should be in proportion to the size of the areas being shaded. Place lines or lines of dots of a crosshatch pattern on a 45° angle. This technique prevents optical illusions that could occur when the lines of the patterns are placed either vertically or horizontally.

In pie chart sectors, place the pattern lines on a 45° angle with the center line of a sector. This technique prevents illusions of having extra sectors, if pattern lines should fall parallel to sector lines.

When using printed crosshatch patterns, cut the pattern just off the lines that separate the patterns, leaving a very thin white line on both sides between the pattern and its boundary line. The illustration will look neater and less cluttered, and also this prevents cut damage to the lines separating the patterns.

4. Curve designs

Select a curve design that is clear and easy to construct and will reproduce well. Chart tapes are very good for this purpose, especially when adjustments are required. (Typical designs are shown in Figure 3.)

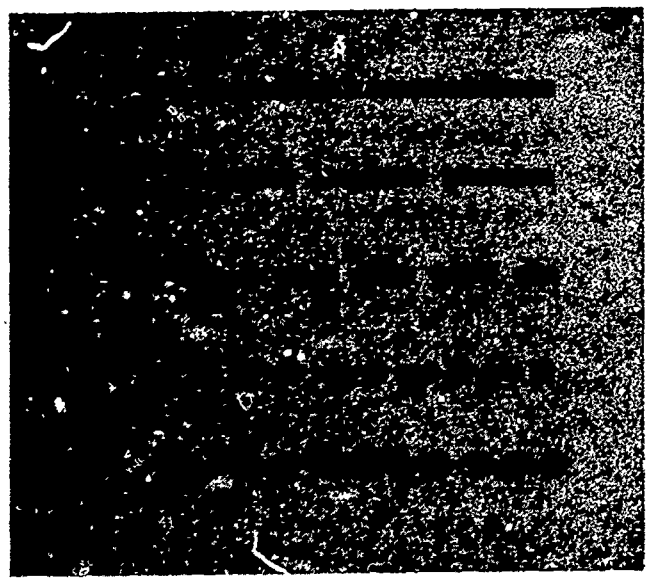


FIGURE 3

When there are two or more curves on the same chart, the curve design will depend a great deal on the positions of the curves. If the curves are widely separated, selecting a curve design is no problem. If, however, two curves almost coincide or cross one another often, curve design should be contrasting—1 and perhaps 3 or 5, of the designs in Figure 3.

5. Order of Inking

Elements of a chart are shown in Figure 4. The order of inking a chart is usually a matter of judgment. The techniques used and the type of lettering will affect the order. Generally, if the chart, including the lettering, is drawn completely in ink, time will be saved by inking the components in the following order:

1. lettering 2. curve 3. grid 4. border

Lettering is inked first, because it should have the right-of-way over all other chart components. Next, the curve is inked because it has the right-of-way over the grid lines. The grid lines should not be drawn through nor touch the lettering or curves.

The border enclosing the chart should be last. If necessary, minor changes or adjustments in the overall proportions of the chart may be made easily before inking the border.

If the lettering is drawn or printed on a separate white paper and pasted on the chart, it may be placed on last because the white background will block out the grid lines.

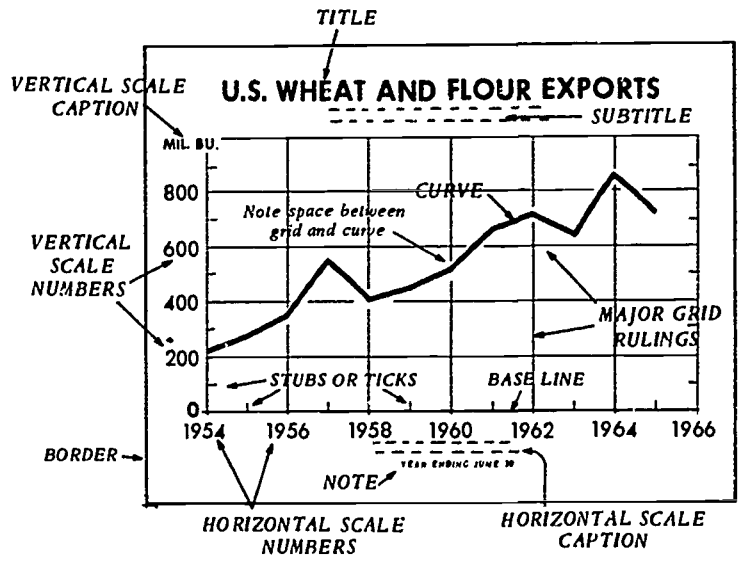


FIGURE 4

TOOLS OF THE TRADE

Interval divider

The interval divider is an excellent and simple device for constructing a plotting scale or for dividing a line or space into almost any number of equal parts. A separate plotting scale is a

time saver and is desirable even when a chart is to be constructed on chart paper. (See Figure 5.)

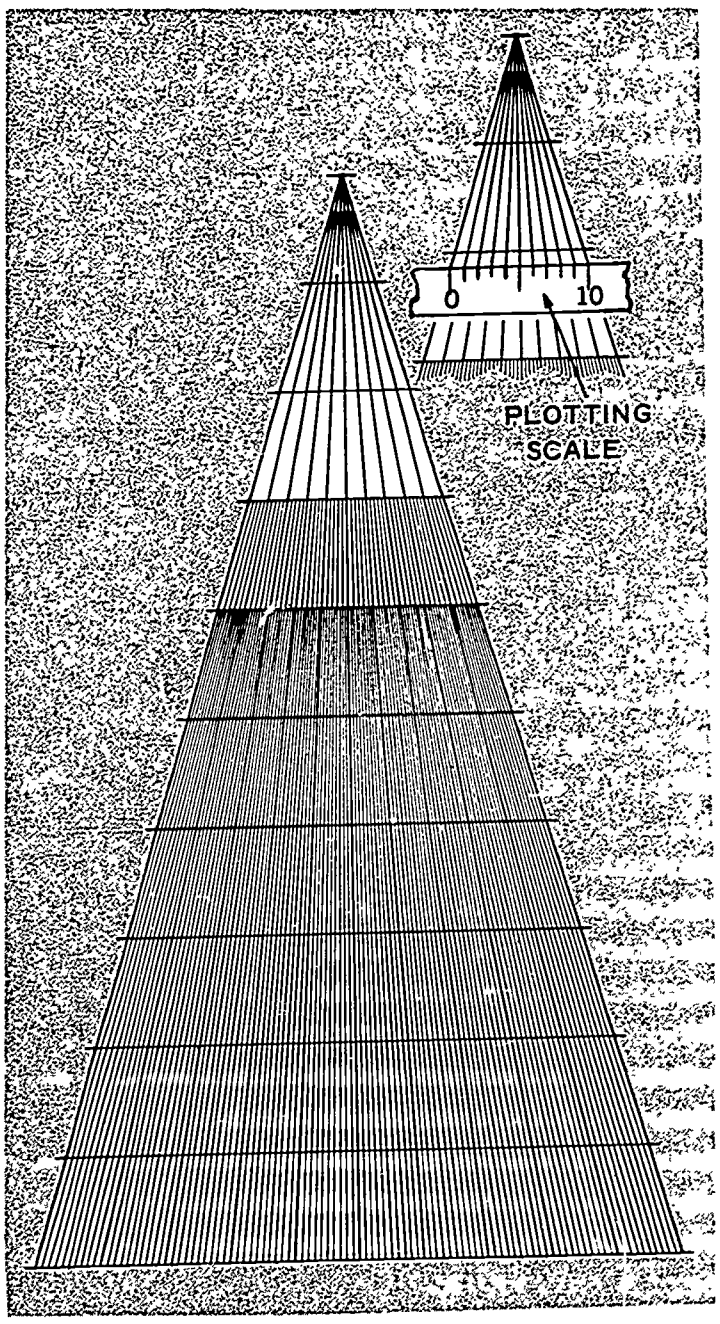


FIGURE 5

Here is how it works: Assume that a plotting scale requires 10 subdivisions. With small ticks, mark off the distance between two major grid rulings of the chart on the edge of a piece of paper. Place the paper on the divider and manipulate it so that the two small marks coincide exactly with the slanting outer edges of the divider and the edge of the paper is parallel to the nearest horizontal line. Holding the paper in this position, mark off the desired subdivisions at each accented line on the divider.

If a plotting scale is to be larger than the limits of the divider, divide the distance in half or into smaller sections; then subdivide each half or portion with the divider.

Sometimes an odd number is desired. Let's use 7 for example. Start on one edge of the divider as zero, count off seven spaces and make the marks on the paper coincide with the edge and the eighth line of the divider. Hold the paper in this position and mark off the 7 divisions at the accented lines. In a similar manner, a plotting scale may be constructed with almost any number of divisions. Likewise, an inch can be divided into any number of parts.

Engineer's scale

An engineer's scale, fully divided, with 10, 20, 30, 40, 50, and 60 divisions to the inch is one of the most versatile measuring instruments available for use in graphic presentation. Inches, divided decimally, are read on the 10 scale. If a line or space is to be divided in half, first measure it exactly with the 10 scale. Applying the same measurement reading to the 20 scale will give the mid point of the line or space. Similarly, the 30 scale will divide it in 3 parts, etc. The 20 scale may also be used to measure the radius of a circle for compass setting. Example: If a diameter measures 1.11″, apply this same diameter measure to the 20 scale to get the radius directly. Regular ruler measures such as ⅛″, ¼″, etc., may be read on the 40 scale: 5/40 = ⅛, 10/40 = ¼, etc. Picas (printer's measure) may be read on the 60 scale as 10/60 = 1/6 = 1 pica = 12 points, etc.

It may also be used to enlarge or reduce a drawing. Example—If all the components of a chart were measured with the 10 scale and these measurements were applied with the 20 scale to a new drawing, the new drawing would be exactly ½ the size of the original. If the 30, 40, or other scales were used instead of the 20, the new drawing would be correspondingly smaller in size. Conversely, if a small drawing were measured with the 20 scale and these measurements were applied with the 10 scale, the new drawing would be twice the size of the original.

CHARTS

There are many kinds of charts. A map is sometimes called a chart. The Air Force calls its aerial maps "Aeronautical Charts"; the Navy names its maps "Hydrographic Charts." A navigator charts a course or plots a course. These are special kinds of charts and are not to be included in this group. Charts, then, employ plotting values of some kind.

Sometimes the word "graph" is used to mean chart. There is no clear-cut definition of either one; there are only opinions. A graph can be thought of as being more diagramatic, more schematic or more technical in nature; it is more closely related to a working tool (curve), used to solve problems in engineering, science, and mathematics.

If we were to classify charts into subgroups, a statistical chart could include graphs, but not the reverse. The word *chart* is more inclusive than is the word *graph*.

Standards vs Design

One of the most important aspects of good chart construction is knowing what is and what is not acceptable.

The ultimate aim of a chart designer should be to construct a chart that conveys information clearly, one that is neat, attractive, simple, self-explanatory, and in line with accepted standard practices.

Chart standards, in general, are common-sense practices and techniques that have been evolved and accepted over a long period of time. They have stood the test of time.

Standards are not meant to state definitely that a chart has to be made only in a certain way each time, but more particularly to suggest that if the standard practice is used, the chart will be better, usually will make more sense, and will be more generally accepted. Nor does it mean that a specific chart should be designed exactly the same way each time one is constructed.

The design of a chart has to do with the overall physical appearance or the artistic qualities; the standard, with the basic rules that govern good chart making. A student with artistic talent has considerable latitude in designing a nice-looking chart that can also be basically correct as far as acceptable standards are concerned. The average chart at best can be dull and monotonous. Any artistic application or medium that will enhance the appearance of a good chart is most welcome. A word of caution: Avoid choosing "way out" designs just to be different.

A model referred to as a standard may sometimes be conflicting, contradictory, or a borderline case that could be argued pro and con. In such cases your decision should be based on ethics and common sense and aimed at eliminating distortions, illusions, and malpractices.

A standard practice can sometimes be "modified" within reason to fit certain special situations. As an example:

> A bar presentation emphasizes linear comparisons that are measured from a zero base line. Because of this, it is a generally accepted practice that *all* bar charts should have a zero base. Omitting the base line or a portion of the grid would create severe distortions in the visual comparisons and analysis. Sometimes in scientific observations that are to be shown over a series of time intervals, there could be an unusually large or "wild" figure that, while important to know, is not significant to the project as a whole. To adhere literally to the standard mentioned above would result in a weak chart that has one extremely long bar and many very short bars that are more significant. The chart should be designed with the shorter but more significant bars in mind, all measured from a zero base. The top of the long bar can be "broken" and extended slightly beyond the top grid line and the figures or value for the same placed near the top of the broken bar. Thus we have conformed to standards by including the zero base but "modified" the standard by sacrificing the top portion of one long but insignificant bar.

Sometimes the same scientific data plotted as a bar chart may also be plotted as a curve or line chart. In this case the visual emphasis is changed; instead of linear measurement from zero, it becomes one of movement or trend. The chart designer may then choose to omit the zero

base and a portion of the grid from the bottom of the curve chart, if the data plots in the top third of the chart. This is a good way to emphasize changes and fluctuations by creating a more sensitive scale. The designer should show a "break" or "tear" line just below the last grid line to call attention to the omission of the zero line. (See Figure 10.) The exception is when the area between the zero and a single curve chart (as in a surface shaded chart) or the area between zero and several curves (strata chart) is to be shaded. Both surface and strata charts must show a zero base line.

There are four quadrants in which charts may be plotted. This diagram serves as a standard for plotting data having plus and minus quantities, or data that show gain or loss, etc. (See Figure 6.)

In a chart utilizing two quadrants, I and II, the plus values should be to the right of the Y axis and minus to the left. In quadrants II and III, plus values should be above the X axis and minus values below. In quadrants III and IV, plus values should be to the right of the Y axis and minus to the left, etc. Additional standard practices and techniques are mentioned under appropriate subjects for convenience.

Charts may be roughly grouped into time-series and non-time-series. Charts whose data are plotted over a series of time intervals are called time-series charts. Time-series charts account for about 75 percent[2] of all charts published. A time-series chart made by plotting data as points and connecting them with straight lines is called a line or curve. A time-series chart with data plotted as bars extending from a zero line is called a bar chart. Time intervals may be in years, months, days, hours, seconds, etc.; they are placed on the horizontal axis or independent variable.

The following selected examples and comments are by no means complete, but they are the ones most often used and should be of some help in selecting a graphic form for your project. The techniques used in their construction are accepted practices and may be used as guides.

Time-series group

■ 1. *Line chart, single amount*

The line chart shows trends or movement over a series of time or other intervals. (See Figure 7.) A line chart may be either a single curve or multiple curves. For designs that can be used when two or more curves are needed, see Figure 3.

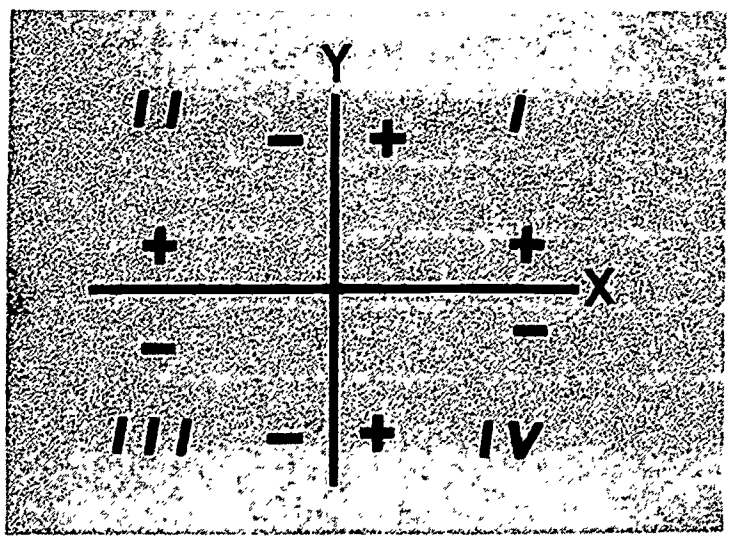


FIGURE 6

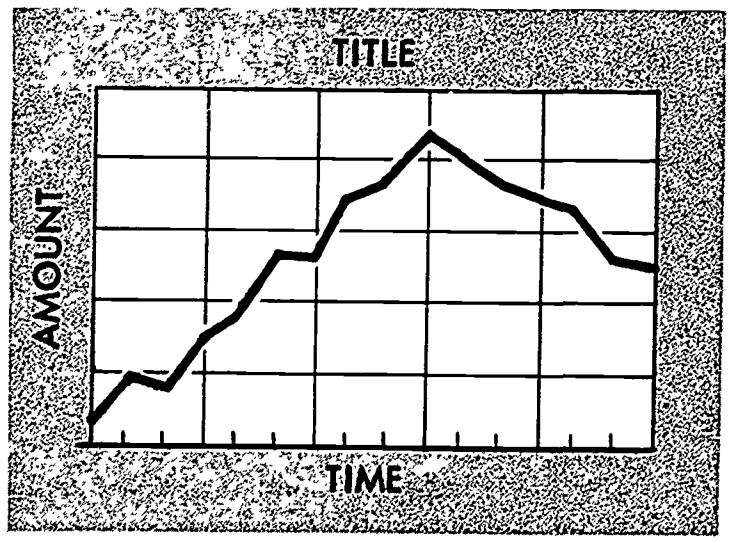


FIGURE 7

[2] *Standards for Time Series Charts.* American Society of Mechanical Engineers, New York. 1948.

■ 2. *Line chart, multiple amount*

This kind of line chart has two curves with two amount scales. They are good for showing two variables with inverse relationships. (See Figure 8.)

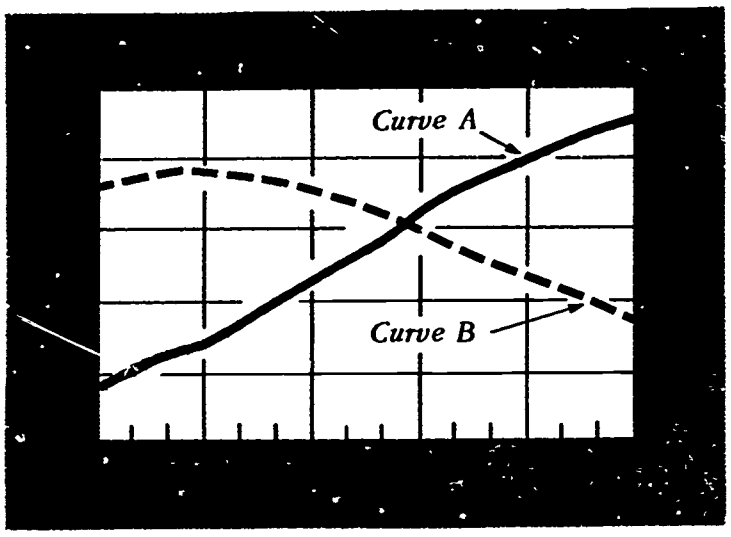


FIGURE 8

■ 3. *Line chart, multiple time*

In Figure 9, the time scale is usually in months with multiple curves, each representing a separate year superimposed on the same grid. The number of years should be kept small. The number of curves will depend on how the data fluctuate; if the curves are well separated, more curves may be added without making the chart too cluttered. This is a good way to make direct comparisons of monthly data plotted over several years. For short-term research, the scale might be days of the week or hours of the day with curves shown for the entire week or month.

■ 4. *Line chart, broken amount scale*

In a line chart, the emphasis is usually on movement from one point to another. If all the data would plot in the top third of a line chart, the zero line and a portion of the grid may be omitted; but the omission should be shown by a tear or break at the bottom of the chart. (See Figure 10.)

■ 5. *Line chart, index*

Data for an index chart are plotted as percentages of a base period. The base period as well as the 100 percent base line should be indicated on the chart. The base period or amount may be indicated as 1960 = 100, for example, and placed inside the grid area, or it may be indicated as on Figure 11. If the base period or amount represents a low point, the rest of the points will plot above the 100 percent base line. If, on the other hand, the base period is the high point in the series, the rest of the points will plot below

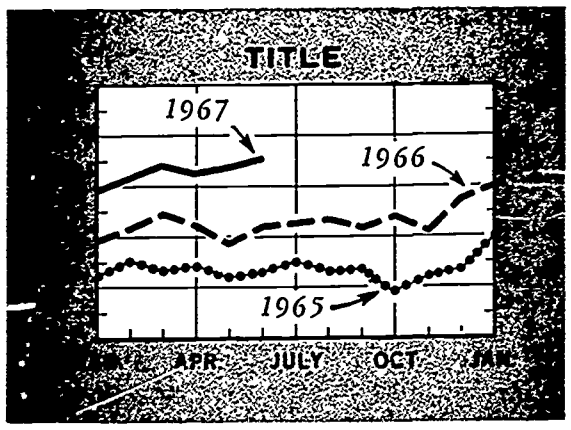


FIGURE 9

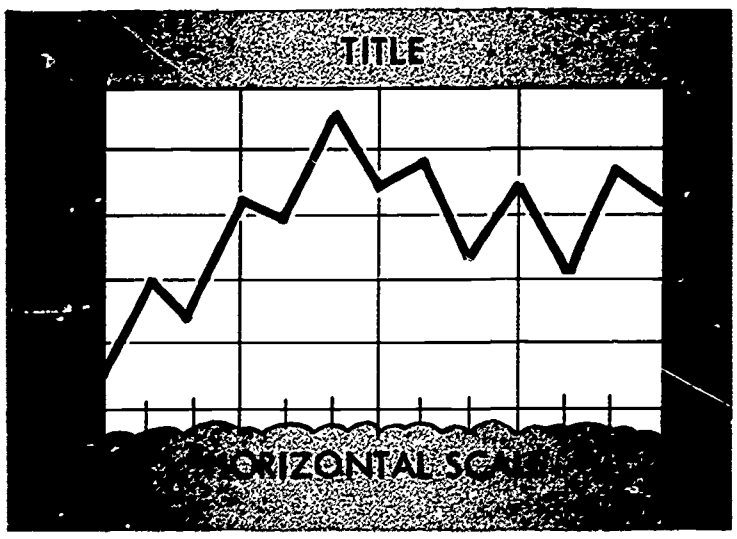


FIGURE 10

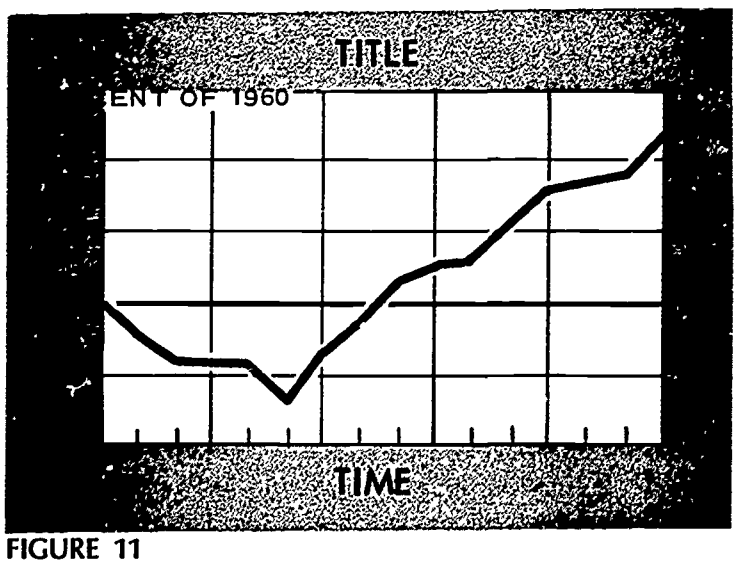


FIGURE 11

the base line. This type of chart might be used for hours of sunlight per time period with a certain number set as 100%; or for changes in density of certain plants over a period of time.

A representative period or amount should be used as the base. Note that the amount scale covers the range of the data only, and the zero need not be included. The tear technique is not used here. The index chart is good for comparison of trends in unlike units against a base period or scale.

■ 6. *Line chart, expanded scale*

This is a two-section chart; the time scale on the left shows a larger time interval (years), while the time scale in the right-hand section is expanded to show monthly data for the current year. The time intervals may also be months and weeks, or weeks and days, etc. This is a good chart to use when additional detail is required. (Figure 12.)

■ 7. *Line chart, zee*

At a first glance this chart (Figure 13) appears complicated, but it is quite simple. The bottom curve shows the actual data plotted by time periods, in this case, in months. The slanting curve shows monthly accumulations. The top curve shows 12-month totals. Data such as monthly precipitation, monthly accumulations, and the current 12-month total compared with the totals for the previous 12 months may be shown.

■ 8. *Line chart, staircase*

Data are for periods of time, and amounts change at regular intervals. (See Figure 14.)

■ 9. *Line chart, silhouette*

A good chart for data that show departures from accepted values, base lines, or an arbitrary base, above (plus) and below (minus). The base line should be emphasized. The amount scale should cover only the range of the data.

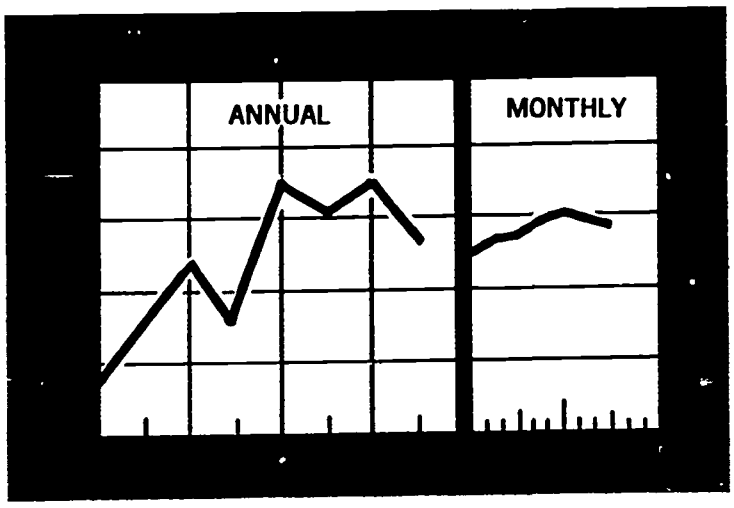


FIGURE 12

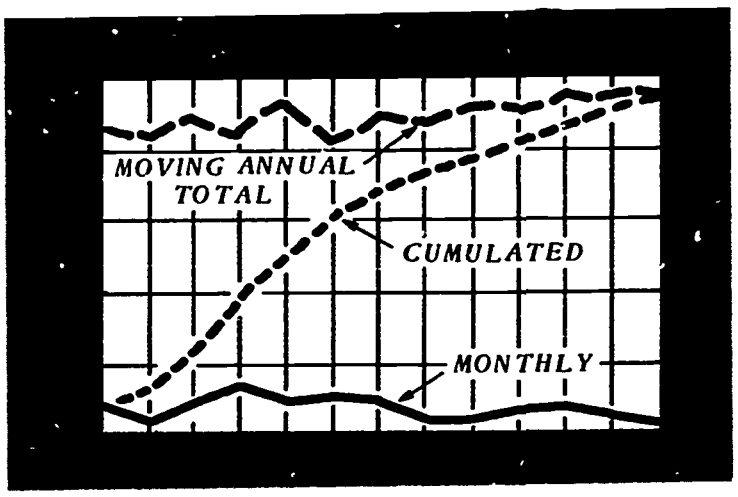


FIGURE 13

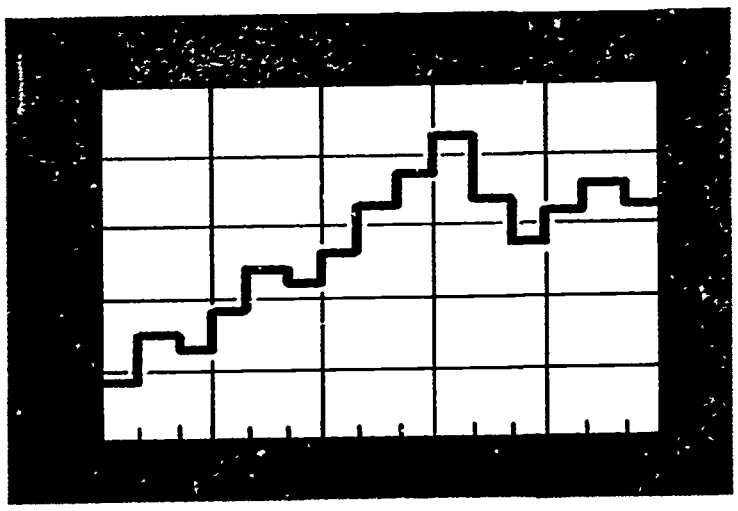


FIGURE 14

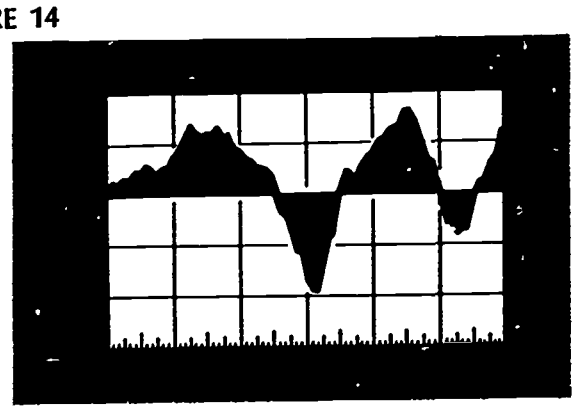


FIGURE 15

■ 10. *Line chart, surface, shaded*

Any single line chart showing *quantities* may be shaded between the curve and the zero base line. A zero base line must be included. The shading helps to call attention to movement as well as measurement from zero. Note—Do not use a shading on line charts showing price.

■ 11. *Line chart, strata (absolute)*

The chart shown here shows absolute data. The emphasis is in movement and the mass or thickness of layers or strata that are cumulated make up a total. The same data could be plotted in the form of a composite bar chart; however, the strata may be used when there are too many data points to be shown clearly as bars. Each stratum should be clearly labeled. The heaviest and topmost curve is the total. The data for each time (or other base scale) interval are cumulated. The first and most important stratum, the only one measured directly from zero, should have the darkest patterns.

■ 12. *Line chart, strata (relative)*

The chart presented here (Figure 18) shows relative amounts or percentages. The entire amount scale from 0 to 100 percent must be shown. The data are in percentages and are cumulated to total 100%. Each stratum must be clearly labeled.

■ 13. *Line chart, zone or band*

Shows the *difference* between two curves. The differences may be above or below a main curve. Each section may be shaded differently to distinguish it from the other. (See Figure 19.)

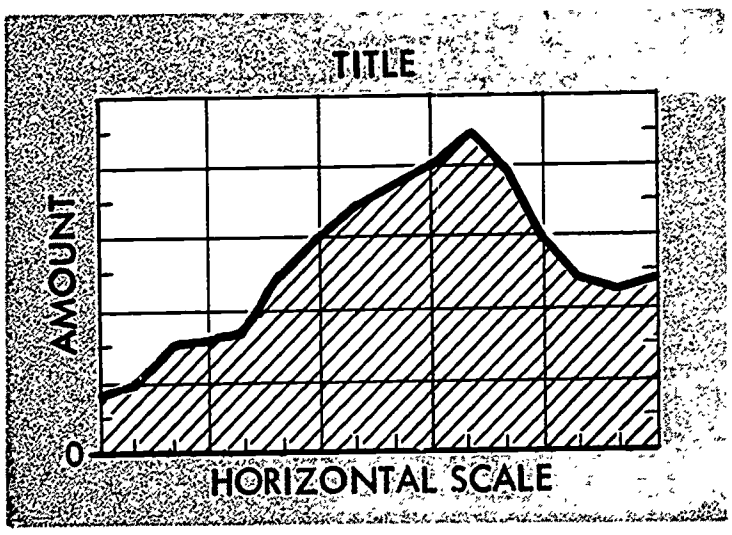


FIGURE 16

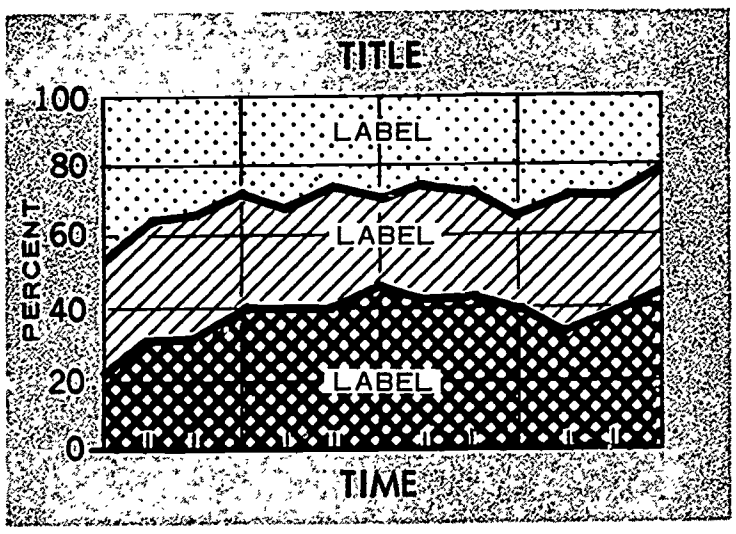


FIGURE 18

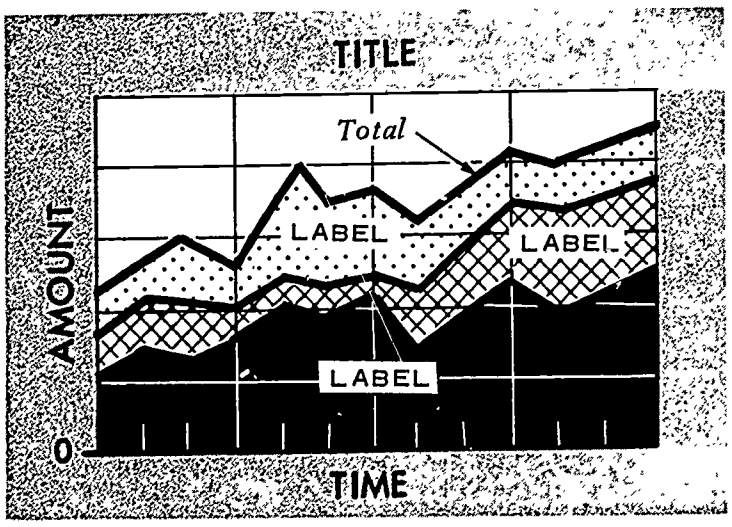


FIGURE 17

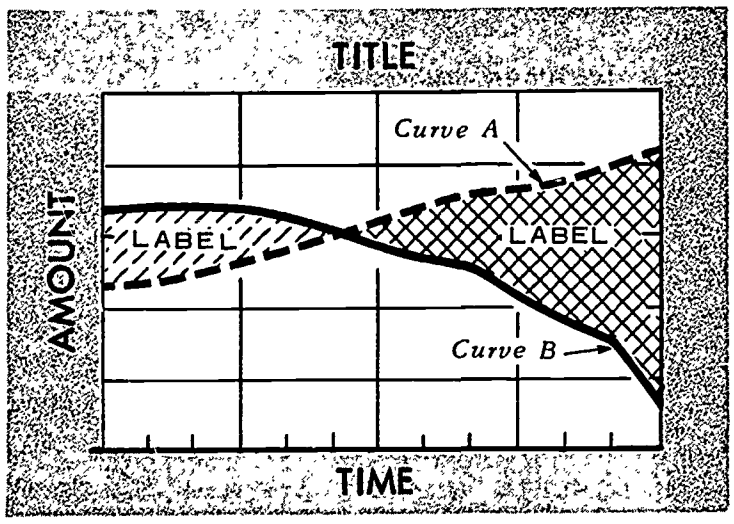


FIGURE 19

■ 14. *Line or bar chart, pictorial*

Any line or bar chart may be made a little more attractive by the addition of a small, simple sketch to represent the subject matter of the chart. The sketch may also be added for balance to fill an otherwise empty corner of a chart. This should not be confused with a pictorial chart where symbols represent values.

■ 15. *Vertical bar chart (single)*

Bars are best used for quantities, while curves are reserved for movement or trend. The times-series (or other base series) bar emphasizes comparisons from a zero base over a series of time or other intervals.

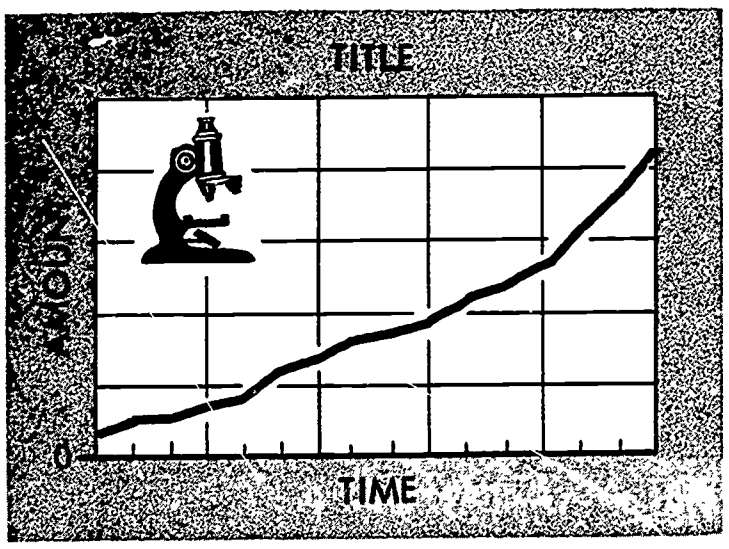


FIGURE 20

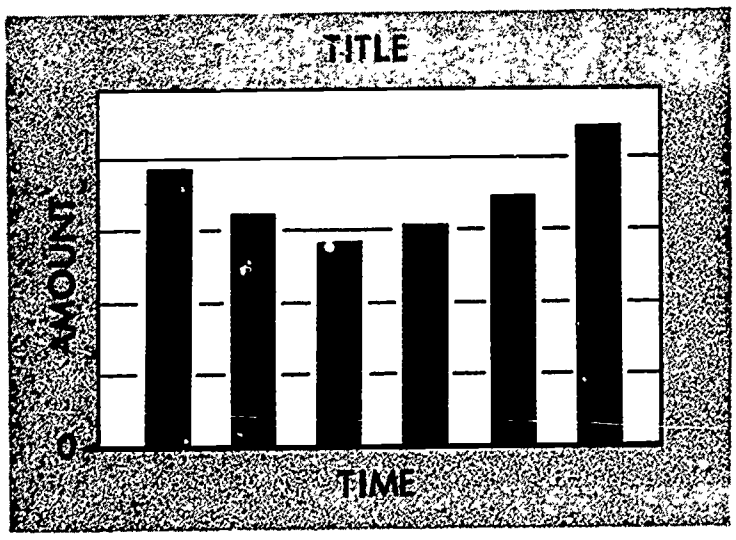


FIGURE 21

■ 16. *Grouped vertical bar chart (multiple)*

The statement made for single bars above also applies to the group bars (Figure 22). There may be two or more bars in each group, for each time interval. Each bar represents a different kind; for example, two kinds of plants produced in one time interval. The bars in each group should be shaded in different patterns and labeled directly or in a key. For different arrangements of grouped bars, see Figure 23. The two bars show how much of each kind, but not a total of the two. This type of chart is good for making a direct comparison of two or more kinds. However, keep the number of bars to a minimum.

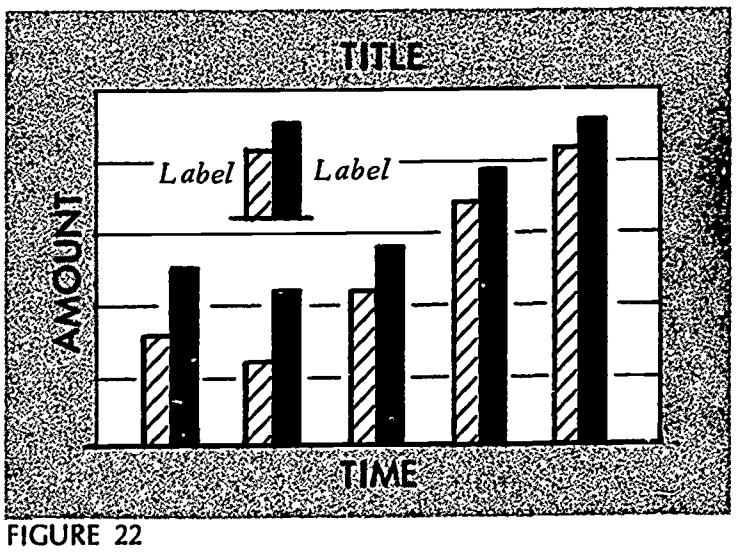


FIGURE 22

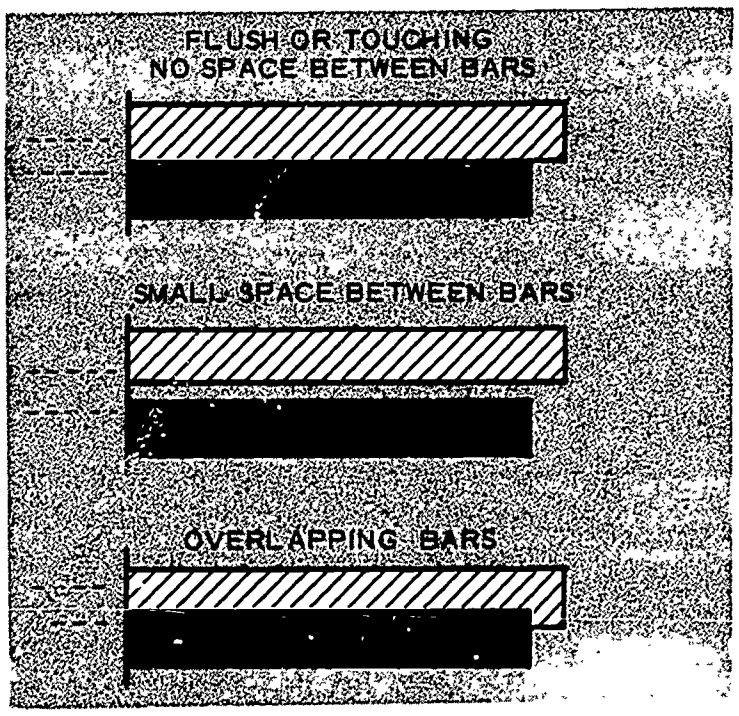


FIGURE 23

■ 17. *Composite bar chart (single)*

Data composed of different kinds adding to a total are ideal for presenting in the form of a composite bar. The data for the group bar mentioned above could be added together and presented as a composite bar. Then each kind would show as a different shading of a single bar. Group bars sometimes have subdivisions that are presented as grouped composite bars.

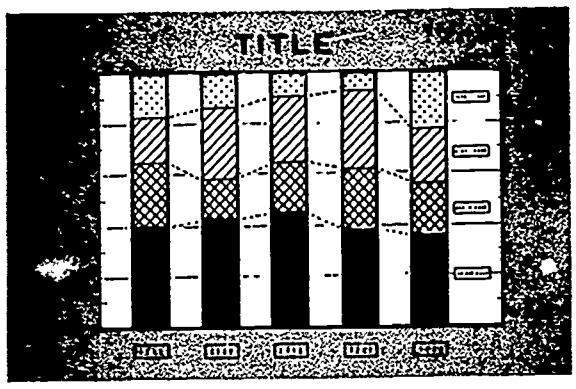


FIGURE 24

■ 18. *Bar and curve chart*

This chart is usually a multiple-amount scale similar to a multiple-line (multiple-amount) chart. Data with inverse relationships are usually well suited for this type of presentation. Bars show quantity and are read on the left-hand amount scale. The curve is reserved for some related but changing value and is read on the right-hand amount scale. A zero base line should be included because of the bars. The plotting point for the curve is the center line of each bar. If the curve goes through bars, it has the right of way.

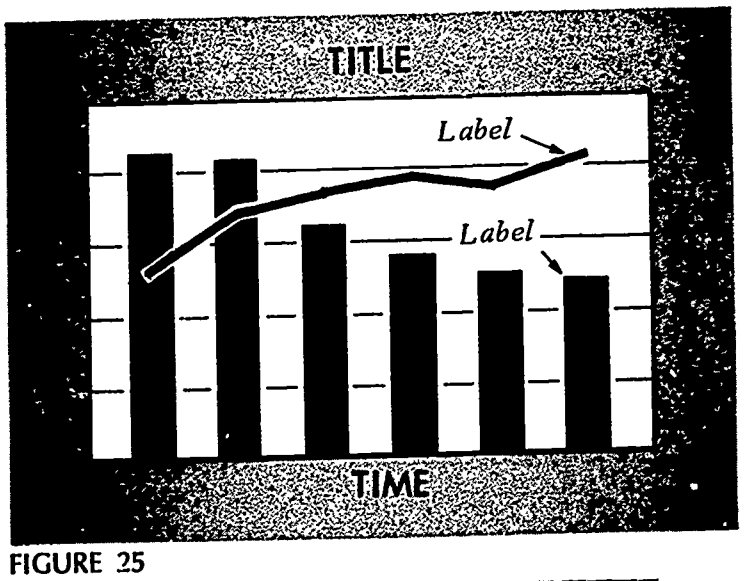


FIGURE 25

■ 19. *Semilogarithmic (semilog) charts*

When data are in absolute figures and the subject of interest is percentage changes and rates of change, time and effort can be saved by plotting these data on semilog paper. (See Figures 26 and 27.) No definite rule can be stated as to when to use a semilog chart, except that if rates of change are to be compared, the semilog is the ideal one to use. Semilog should not be used to compare absolute amounts that differ widely in magnitude. Perhaps the following list of characteristics will aid in the analysis of the completed chart.

1. Semilog charts have an arithmetic scale on the horizontal axis and a logarithmic scale on the vertical axis.
2. A semilog chart has no zero line. Therefore no minus quantities as such may be plotted, and no bars

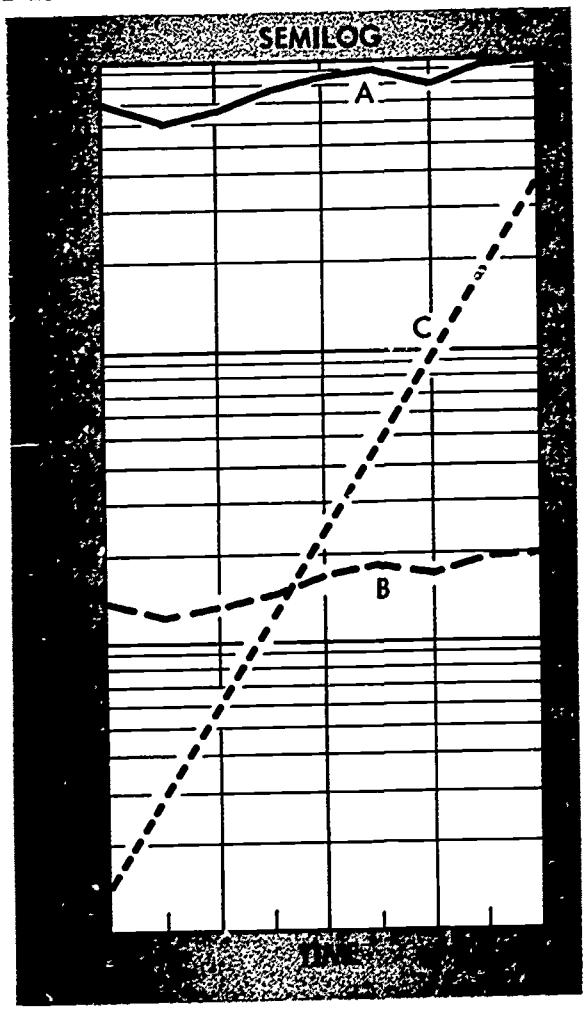


FIGURE 26

are used. Semilog is strictly a curve chart with emphasis on slopes of lines.

3. Each deck, tier, or cycle is 10 times the previous one.
4. Data in the form of a geometric progression (150, 300, 600, etc.) form a straight line when plotted on a semilog chart (curve C, Figure 26).
5. Increases at a constant rate (5%, 10%, etc.) also produce a straight line. (The same data plotted on an arithmetic chart would produce an upward curve similar to curve C, Figure 27.)
6. Increases by fixed amounts (10, 20, etc.) produce an upward curve falling to the right. (The same data on an arithmetic chart would produce a straight line.)
7. All 100-percent changes are equally spaced on the same chart. Example: The distance from 1 to 2 is exactly the same distance as that from 2 to 4, or 3 to 6, or 150 to 300, etc. This is also a good accuracy check for the grid ruling spacings.
8. Equal rises and equal falls anywhere on the same chart indicate equal percentage changes.
9. Parallel slopes of lines indicate equal rates of change.
10. Visual comparisons of absolute quantities cannot be made on a semilog; use an arithmetic chart for a comparison of absolute quantities.
11. Changing absolute data to logarithms and plotting them on an arithmetic grid would produce a curve with the same properties as absolute data plotted on semilog paper.

Commercially printed semilog paper is available in various colors and in single and multiple cycles. To simplify fitting a range of data (Example—9 to 99), to semilog rulings, multiply the small numbers identifying the major grid rulings by any convenient multiple: Major ruled lines marked 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, etc., when multiplied by 5, become 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 100, etc.

In some instances, the semilog chart may be used as a tool for analyzing the data and to check for points that might otherwise go unnoticed, such as parallel slopes or equal rises; indicating equal rates of change and equal percentage change.

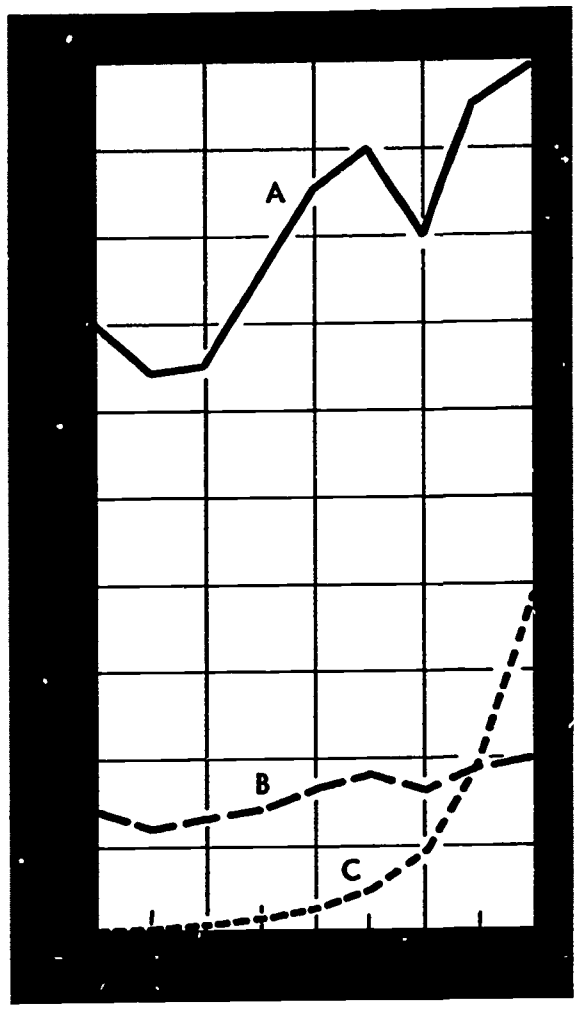


FIGURE 27

Non-time series group

■ 20. *Horizontal bar chart (single)*

Simple comparisons of a number of items for one period of time are best presented by the use of horizontal bars. There is ample space at the left to label each bar clearly. Arrange the bars in decreasing order of magnitude when possible. Since

the longest and most important bar is at the top, the scale should also be placed at the top of the grid. (See Figure 28.)

■ 21. *Grouped horizontal bar chart*

The same statement made for grouped vertical bars in time series also applies to grouped horizontal bars not in time series. Grouped horizontal bar charts, however, have two or more bars for each item and not in a series of time. (See Figure 29.)

A grouped horizontal bar chart not in time series is excellent for showing a direct comparison of two or more subgroups of separate items. It does not, however, show a total of the subgroups.

Single or grouped horizontal bar charts may also have subdivisions. When subdivisions are shown, the bars are called composite bars. Bars may be presented in absolute values or relative values. The amount scale for relative values should show the complete range from zero to 100 percent.

■ 22. *Sliding bar chart*

This is a relative or percentage chart where different items are represented by bars of equal length, each representing 100 percent. Each bar usually has two major components, but in some instances the components may have minor subdivisions. (See Figure 30.)

A zero vertical base line forms the dividing line between the major segments. The amount scale starts from zero and shows percents in opposite directions to cover the data range of the major segments. Examples of data that may be shown by the use of sliding bars are—percent of the dollar spent for food and nonfood items by income groups, or production and exports.

■ 23. *Bilateral bar chart*

Data that could be shown as grouped bars may also be adapted and shown as a two-section chart where only one list of labels are used for both sections. Bars may be single, grouped (two periods of time), absolute, relative, or composite; Figure 31.

The two-section chart may have the labels for the bars placed between the sections, as in Figure 32. In this instance, the bars for each item are in opposite directions.

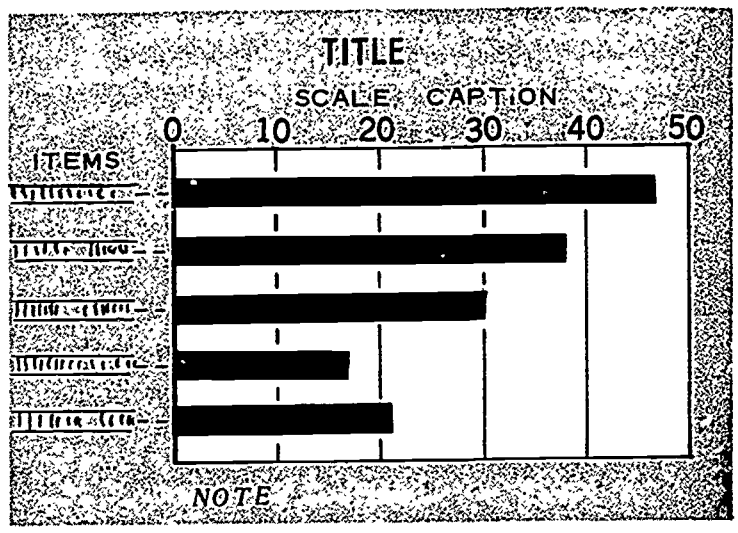


FIGURE 28

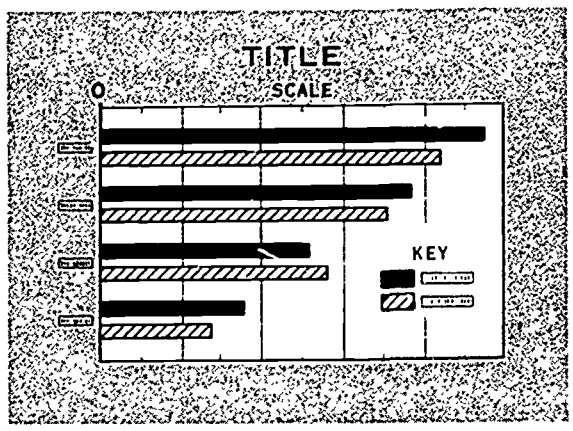


FIGURE 29

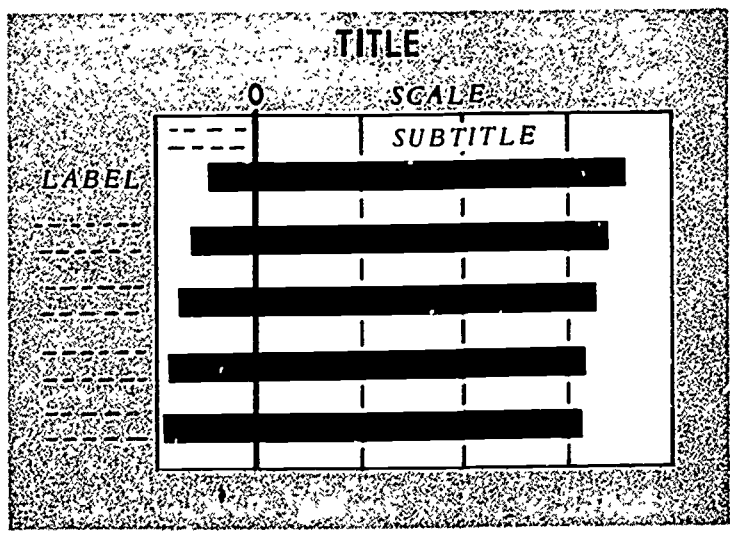


FIGURE 30

Labels for the bars may also be placed at the left of two adjacent sections. The bars in each section are then in the same direction. In either case, there are disadvantages in that it is a little difficult to compare the bars in one section directly with the bars in another section. Also, when the sections are adjacent, the bars are farther away from the labels and thus more difficult to follow. Each section should be labeled with an appropriate subtitle.

Data with two major subdivisions, such as production and yields of wheat by major producers, or prevalence of algae in two lakes, for example, may be shown in a bilateral bar chart. The bilateral bar permits an uninterrupted direct comparison of the bars in each subdivision on its own grid. However, it is a little more difficult to relate one to the other, especially when one set of bars runs in the opposite direction.

24. *Pictorial charts*

This is a chart that uses a symbol or generalized schematic sketch of an object to represent a quantity and to make more attractive an otherwise drab chart. A good pictorial chart is one showing a simple comparison that is quickly and easily understood. (See Figure 33.)

Most data that could be shown in a simple horizontal bar chart could be adapted to a pictorial presentation. Highly technical data, however, or data with extremely wide differences, are not good for pictorial presentations. There are four general types of pictorial symbol charts:

1. *Multiple symbol*—where one symbol equals a given quantity and the value and number of symbols proportional to the amount of the data. If the symbols are placed side by side, close together but not touching in groups of 5, the chart will be easier to follow. Fractions or partial symbols, depending on the shape, are usually kept to increments of about a ¼ of a symbol. Therefore, pictorial charts represent only a close approximation of the total. Grid lines are not usually shown. However, the symbols should have a common

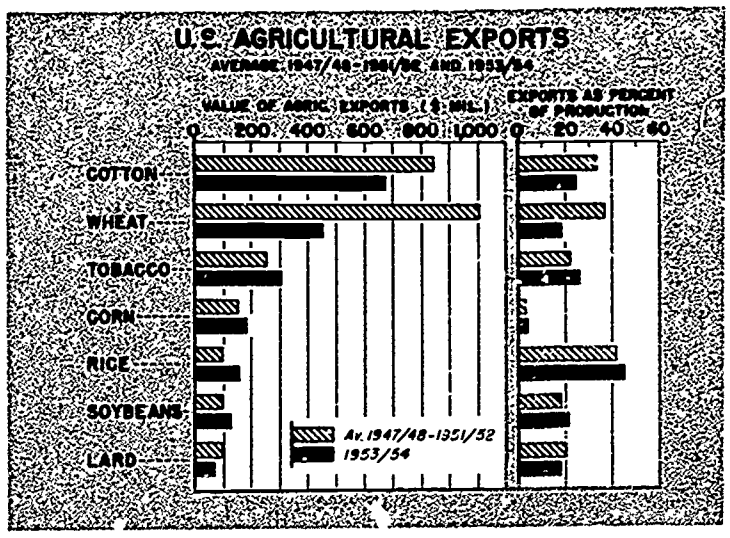


FIGURE 31

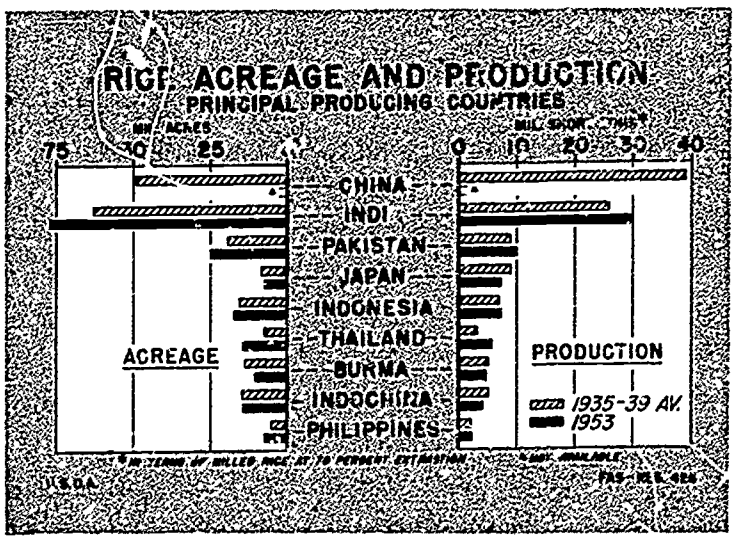


FIGURE 32

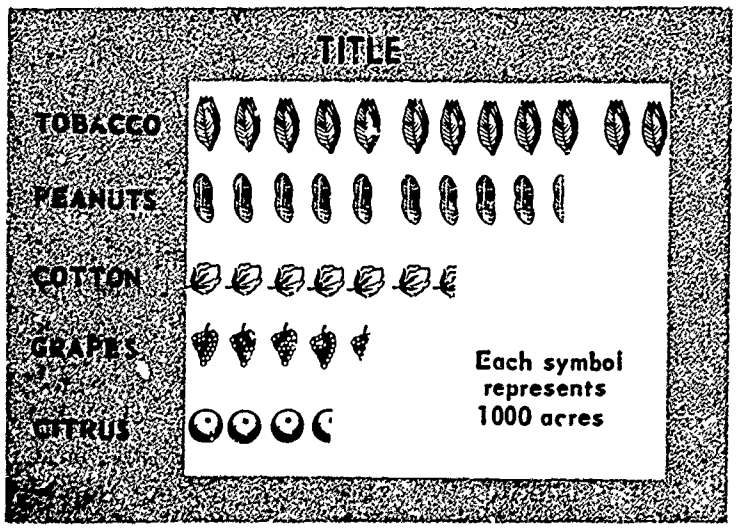


FIGURE 33

starting position even if the starting line is not shown on the final.

2. *Grouped symbols*—A symbol such as a man, woman, and child grouped together is used to represent number of families. The technique is generally the same as above for multiple symbols.
3. *Area symbols*—The use of area symbols is often abused and the final presentation can be misleading if not constructed properly. One of the best ways to control the proportion of an area pictorial symbol is to use proportional circles as guides. The same formula used for the construction of a pie chart may be used here for the proportional circles. The sizes of the circles are made proportional to the data, as one is to four, and the symbol is constructed within each circle, after which the circles are removed. Symbols need only enough detail for recognition. Keep them simple and neat.
4. *Pictorial sketch*—A pictorial sketch or symbol of the subject being portrayed may be used for decorative purposes, such as to fill an empty corner of a chart, or a sketch may be added near a curve to attract attention and emphasize a point; or it may even be part of the title. Sketches may be artist's sketches or simple symbolic sketches, or anything in between. The sketches do *not* represent statistical quantities, but are used only for decorative purposes.

■ 25. *Pie charts*

When the emphasis is to be placed on the whole figure as well as component parts, then perhaps the choice of presentation could be a pie chart. (See Figure 34.) Here again the professional follows certain basic rules or accepted practices to simplify the presentation and avoid confusing the reader.

In the pie chart, sectors start at 12 o'clock and should be arranged clockwise in decreasing order of percentages with the "all other" figure last regardless of its size. The starting line, 12 o'clock, should be emphasized by making it heavier than the other sector lines and extending it a short distance beyond the perimeter. The data are in percents and should be cumulated to 100 percent.

When only one circle is to be presented, it can be any convenient size. However, if two or more circles are to be compared on the same chart, their diameters must be made proportional to the total amounts of the data. The formula follows:

$A:a = D^2:d^2$; where A = amount of larger circle, a = amount of smaller circle, D = diameter of large circle, d = diameter of small circle.

The base of the circles should rest on a common horizontal line, for ease of comparison. Whether or not this line is shown on the final is a matter of choice. A total figure may be placed below each circle in lieu of an amount legend.

The circles are compared by relative areas; the sectors, by percentages. The pie chart is a good choice when emphasis is in relation both to the whole figure and its relative parts. A percent figure and a label should be shown for each sector. Labels may be placed inside or outside of the sectors as space permits.

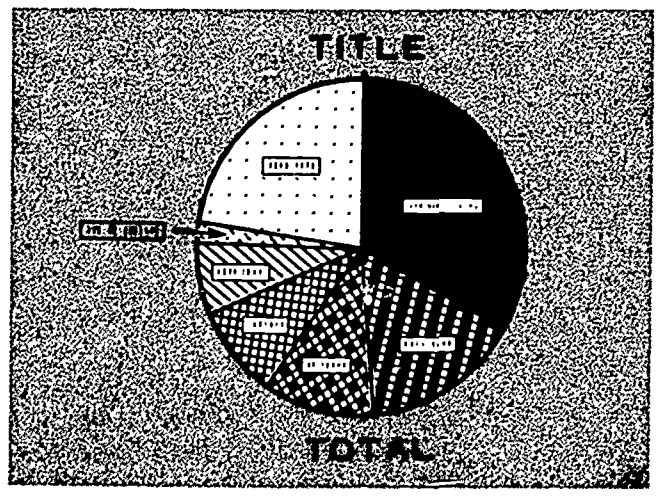


FIGURE 34

26. *Frequency chart*

Frequency charts are used when data are for a large number of observations and the emphasis is on how many times a phenomenon occurs. Frequency charts, whether they are called rectangle frequency charts (histograms) (Figures 35 and 36), frequency curves (Figure 37), or frequency polygons (Figure 38), are all prepared in the same general form.

The first step in preparing data for the construction of frequency charts is to arrange the observations in order of magnitude. The data are then grouped into convenient class intervals which are plotted along the horizontal axis of the chart. The vertical axis shows how many observations there are in each class interval.

Careful selection of a suitable class interval value is important to the effectiveness and appearance of the presentation. The best selection is usually achieved by experimentation. If the intervals are too wide, there will be too few groups and a loss of distribution. If there are too many intervals, the presentation loses effectiveness and tends to be confusing and more difficult to analyze.

The final presentation may be in the form of shaded columns (Figure 35), step curve (Figure 36), smooth curve (Figure 37), or rough curve (Figure 38).

The vertical scale should show a zero base line. Including the zero line on the horizontal scale is a matter of judgment. However, without the horizontal zero, the chart is not truly a graphic presentation of the central tendency or of its complete relationship to the entire distribution.

Data for frequency charts may be either a continuous or discontinuous series. In a continuous series the measurements occur at all possible points. An example—data dealing with the heights and weights of people.

A discontinuous or discrete series is probably best demonstrated by the throwing of dice. It is never possible to obtain anything but a number of whole spots, never a part of a spot. The class interval for the continuous series would depend on a convenient grouping of persons by height or weight. The selection of class intervals for the discontinuous series would have to be based on various combinations of spots on the dice.

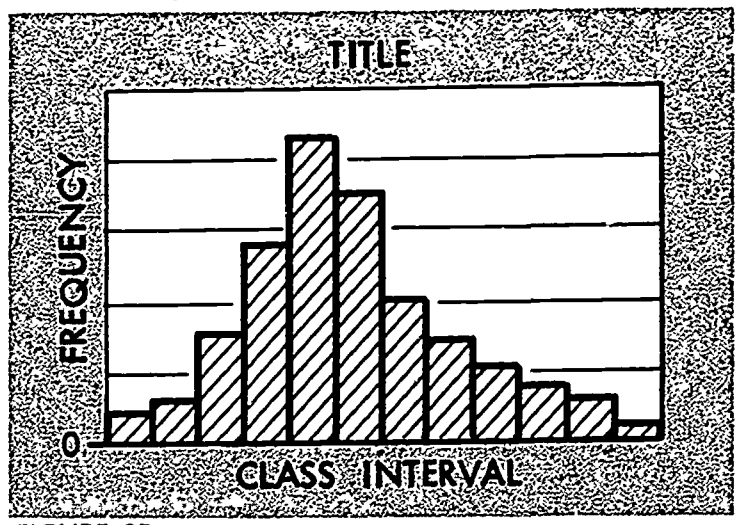


FIGURE 35

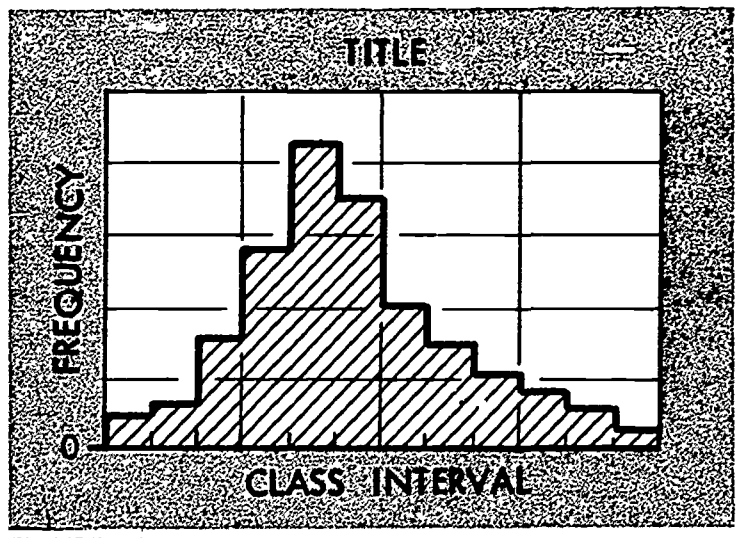


FIGURE 36

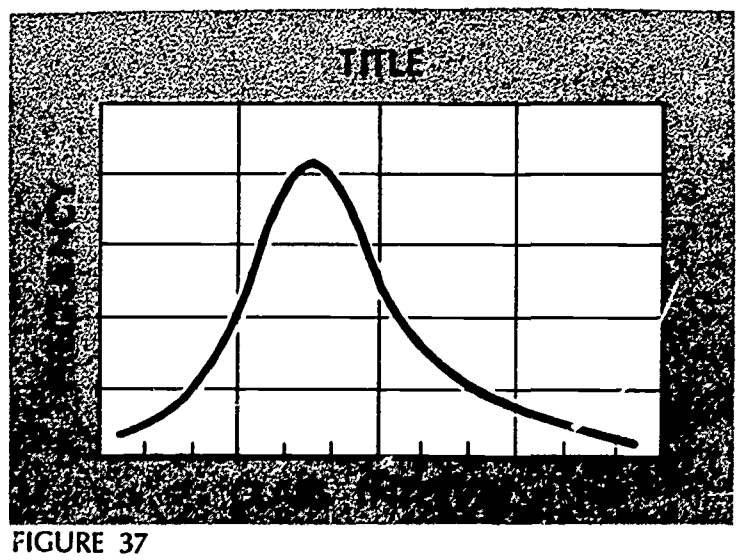


FIGURE 37

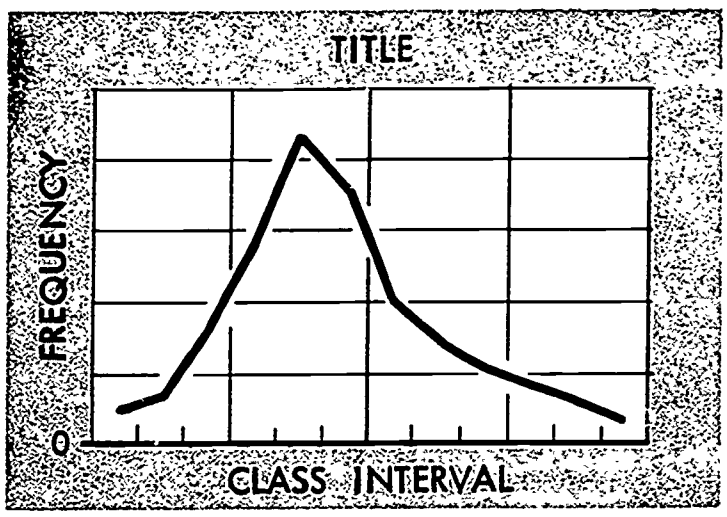


FIGURE 38

■ 27. *Line chart, correlation*

This is an analytical chart used to show the relationship between two or more variables and usually for a large number of observations. (See Figure 39.) Examples: A study of plant yields versus the amount of fertilizer applied; a study of gas con-consumption versus the revolutions per minute. Fitting a trend line to the plotted data, whether a straight line or curve, is a statistical function, although it may also be fitted freehand.

Two plotting scales are required; one for the horizontal scale values, the other for the vertical scale values. The intersection of lines drawn through the plotted values for each variable locates the position of the plotting point of the two variables. Sometimes each dot has to be identified by a number or letter so it can be located and referred to later.

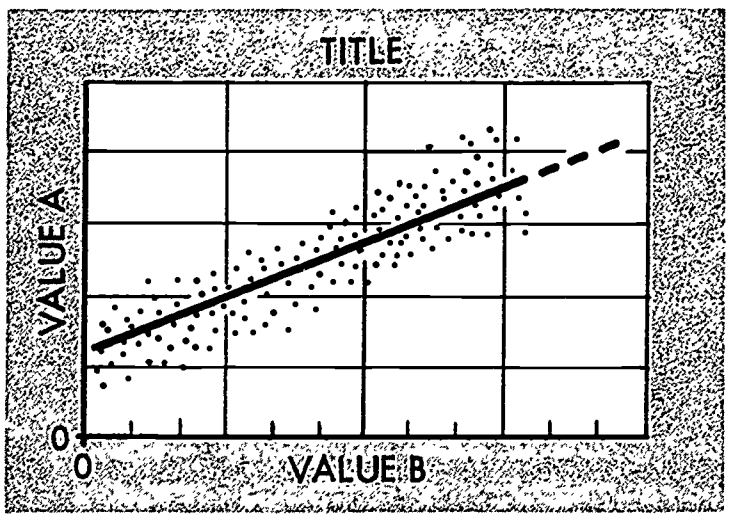


FIGURE 39

MAPS

Maps are used to portray data with geographic locations or areal relationships. They are excellent to use in presenting data for a large number of observations that could not be satisfactorily presented in any other manner. Example—data for each of 3,050 counties of the United States.

It is not the purpose here to discuss all phases of mapping. There are many good books published on the subject. As far as graphic presentation is concerned, there are two major groups of maps that should be considered—statistical and geographic.

Statistical maps

A statistical map is essentially any graphic form constructed from statistical data and placed on a generalized outline base map. Geographic location of the data by latitude and longitude coordinates is not required nor implied. There is also little need for a mile scale, coordinate lines, or any other fine map detail.

The outline map is used only as a convenient medium on which to place shadings or graphic forms. Statistical maps could include the use of the following more popular graphic forms: bars, circles, symbols, charts, dots, flow lines, or crosshatching.

Bars for map areas (See Figure 40.) may be any of the following:

1. Simple single bars, either all black, shaded or colored;
2. Grouped bars, with two or more placed side by side to represent subgroups for one item, such as the amounts of two kinds of wheat or species of plants that are grown or found in an area;
3. Composite bars, where two or more parts make up the total bar. Single or grouped bars may also be composite bars.

The longest bar or bars that will fit into the smallest area or into a congested area usually determines the scale for the rest of the bars in the series. If necessary, the scale of the key bar may be made larger (thereby increasing the size of the bars in the rest of the series) by placing it ouside of the political unit at some convenient place. In this instance an arrow should be drawn

from the bar to the political unit. Bars may also extend into or "spill over" into the surrounding areas as long as they do not interfere with other bars.

It is obvious that a bar could not be constructed for each county on a small map of the United States. The data would have to be combined by states to make them more manageable. However, a bar may be shown for each county of a larger state map. An appropriate legend should clearly indicate what the bars represent. A total figure may be placed under each bar to aid the reader. The figures could be in addition to or in lieu of a vertical grid.

It is more expedient to construct bars, circles, and other graphic forms for maps on a separate sheet of drawing paper. The completed graphic forms are then trimmed carefully and neatly, leaving about 1/20" of paper all around, and then arranged on the map and glued into position with rubber cement. This technique will enable one to shift or adjust the positions of the graphic forms to the best advantage. The white paper background will also show the graphic form more clearly by blocking out the boundaries which could interfere with the presentation.

Circles may be used as a substitute for bars in some instances. (See Figure 41.) The same techniques that are used for the construction of a circle and pie chart also apply to circles or pies for a map. In general, determining the correct size and placement on the map is essentially the same as that mentioned for bars above. In the final analysis, however, it must be remembered that if one circle is twice as high as another one, the data for the large one are four times as large.

Pictorial and geometric symbols are placed on maps to represent a generalized picture of a situation and to attract attention. Each symbol represents a convenient value, such as 100, 1,000, 2,000, etc. Multiple symbols are then placed side by side in groups of five to represent the total data for a given area. See section on pictorial charts for other details on the construction and use of symbols. Because of space requirements,

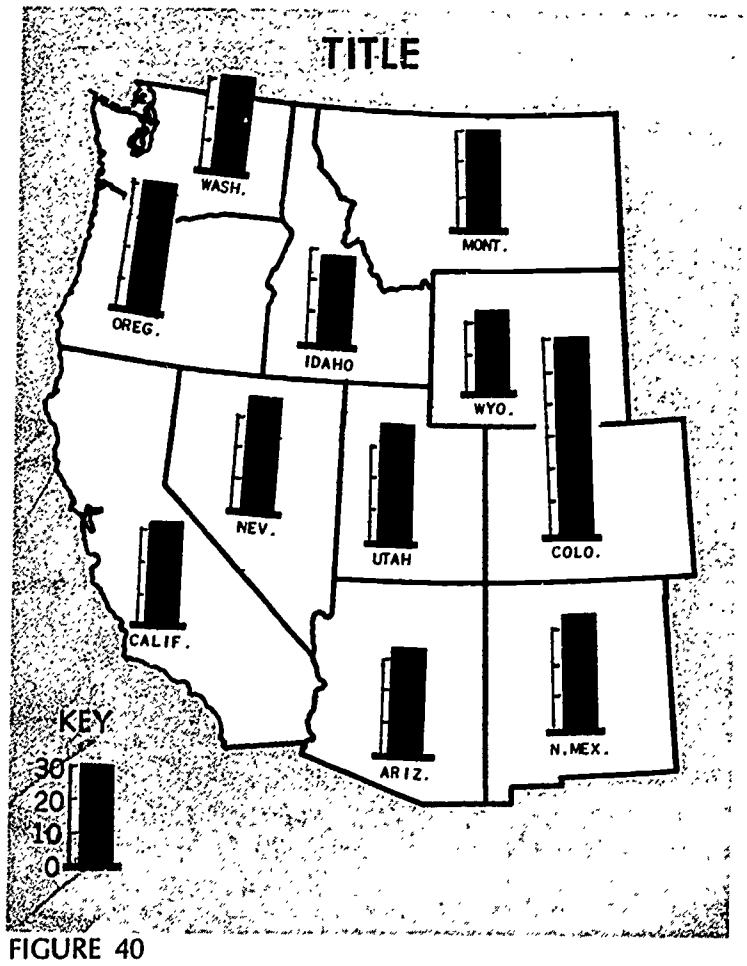


FIGURE 40

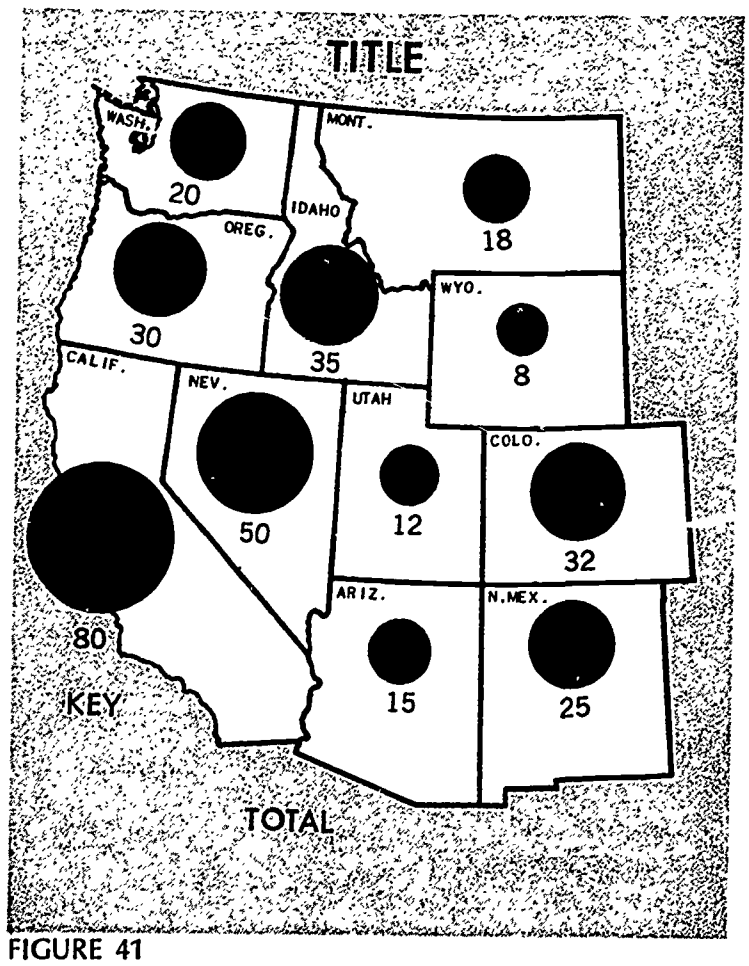


FIGURE 41

pictorial symbols are usually reserved for maps with larger political units.

Charts of almost any kind may be used on a map, but keep them simple. Charts may be used to represent trends of a country or region, etc., such as a five-year trend of wheat yields or pollution levels in air in separate regions of the United States. A small complete legible curve chart may be placed in each region to show the trend.

Dots can be used on maps for a presentation similar in many respects to a density crosshatch. The dots are not located by geographic features. Instead, dots representing a given value are distributed uniformly within an area without regard to any geographic location. This type of dot map shows density areas only. (See also geographic dot maps.)

Flow line maps (See Figure 42.) are used to show relative amounts and movement from one location to another, such as international trade or migrations of birds. The flow lines for trade need not follow regular shipping routes unless, of course, routes and distance are specific factors. Circles or bars may be placed in an area to represent total movement. The formula used for determining the size of circles for a pie chart or circle map is also used here for the circles of a flow map.

The flow lines represent movement, such as shipments or migrations. The flow lines are made proportional to the amount or cumulated amount flowing in any given direction. Supplemental data may be added with the bars or near the flow lines to show additional details.

An engineer's scale, fully divided, with 10, 20, 30, 40, 50, and 60 divisions to the inch, is excellent to use for plotting the widths of the flow lines. Cumulated value figures may be placed on or near the flow lines to aid the reader. A clear legend for both the circles and flow lines should be included.

Crosshatching is used to compare statistical values by density of crosshatch patterns or to show extent or area. The first and most important step in the construction of a good crosshatch map is the selection of a legend interval. In many respects, the steps used to select a map legend interval are like those used to select a class interval for a frequency chart.

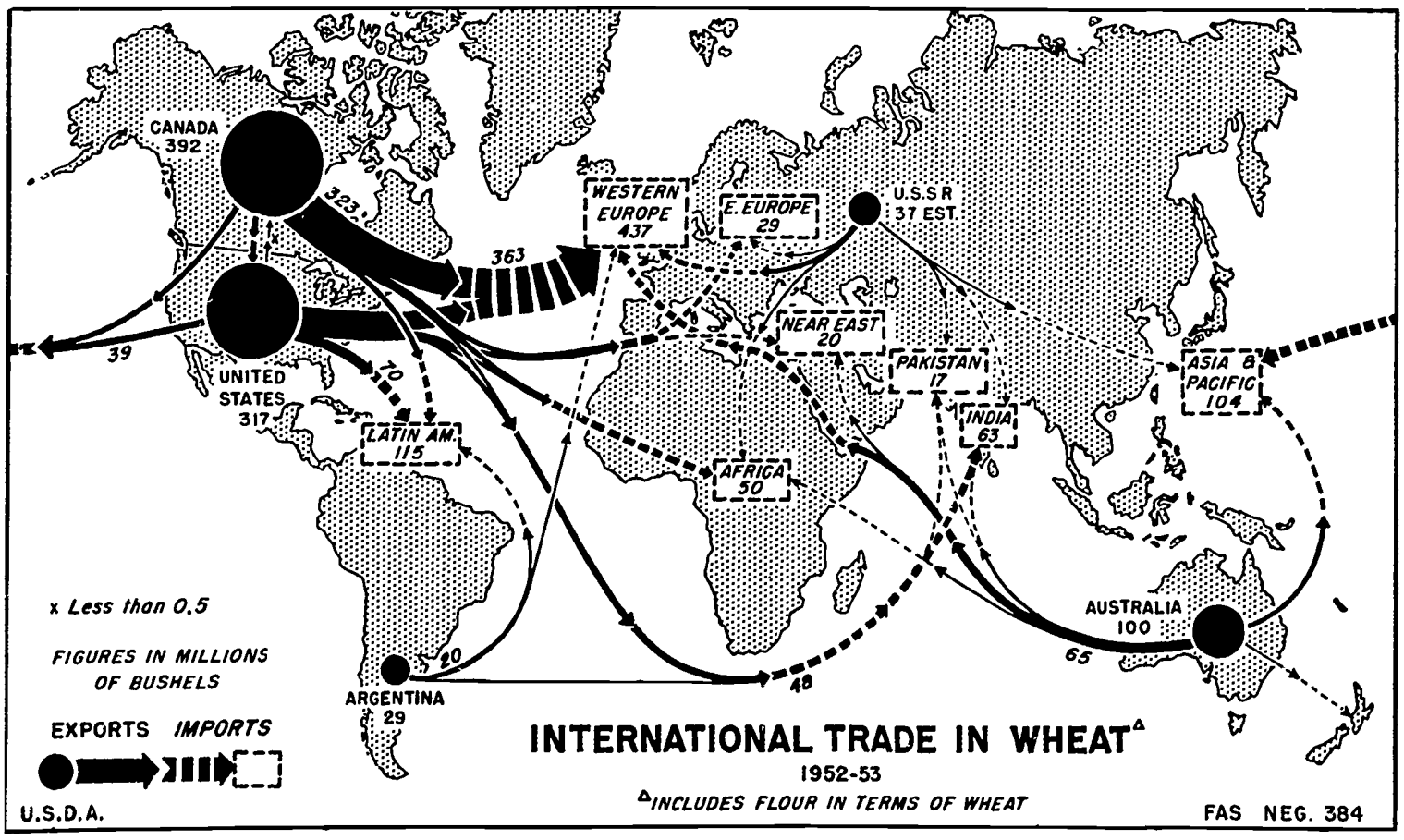


FIGURE 42

It would be impossible to have a separate crosshatch pattern for each statistical observation. Data have to be grouped so that the map will show fewer units. To simplify the presentation, data should first be arranged in order of magnitude and then grouped into even intervals such as 5s, 10s, 100s, etc. A good legend interval is one that will produce fewer than 10 patterns and at the same time show a uniform distribution of patterns on the map. The physical appearance and effectiveness of the map will depend a great deal on skillful selection of the legend interval. If the interval value is made too large, there will be too few patterns with a corresponding loss in distribution. Lower values are "mulched" in with higher values, and highest values are obscured in a like manner. A map of this type could be very misleading in the final analysis.

If, on the other hand, the interval value is made too small, there will be too many intervals. One would experience difficulty in selecting a density range of crosshatch patterns for a large number of legend intervals. There would not be enough visual differences between the tones of each pattern. The map would be more difficult to construct and would result in a confusion of patterns that would be difficult to analyze. There has to be a happy medium between the number of intervals, the value of each interval, and the scale of the map. Keep the selection to a relatively few but enough to make a well-balanced map.

A good crosshatch map may lose its effectiveness if the legend itself is not absolutely clear. There are several ways to construct a map legend. The example in Figure 43 shows three forms of legend layouts.

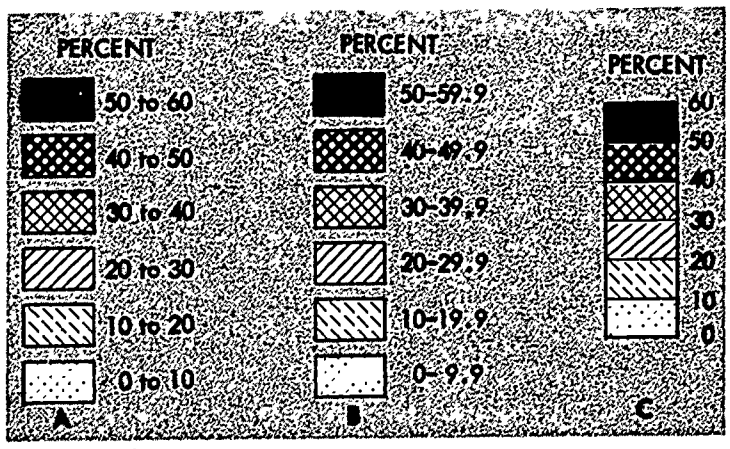


FIGURE 43

Each legend has the same density range of patterns and each is in correct form. However, legend C is the easiest to construct, has fewer numbers, takes less time, and is easier to follow. The legends shown may be used for either statistical or geographic crosshatch maps.

- Kinds of crosshatch maps:

  1. *Maps by major political units*—When data values are by major political units, such as countries, states, etc., the state or country boundary forms the outline for the crosshatch patterns. The state or country boundaries are also shown on the final presentation as in Figure 44.

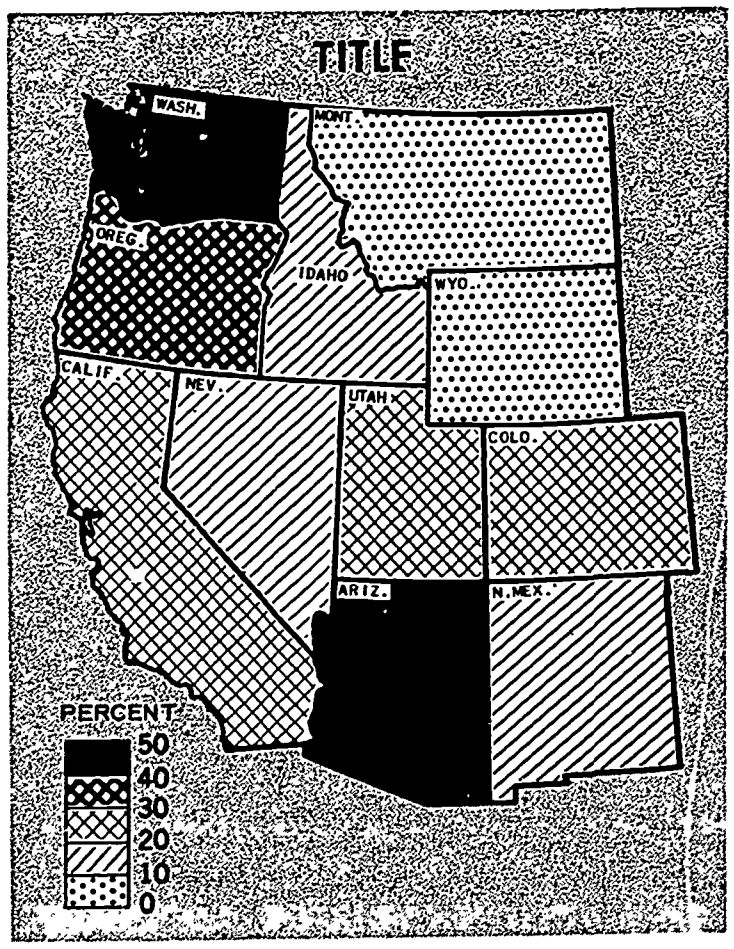


FIGURE 44

  2. *Maps by minor political units*—When data are for numerous smaller divisions, such as counties or districts, the counties are first grouped together according to the values as they apply to the legend. To simplify the presentation, a light line is drawn around the groups of counties that are to have the same crosshatch pattern. This line forms the boundary for each pat-

tem. The county boundaries need not be shown on the final; however, the boundaries of the states are shown. The decision of when to show boundaries is a matter of judgment and will depend largely on the scale and type of map.

3. *Area maps*—When data represent different kinds (example: predominant plant groups by counties), area crosshatch patterns are used. The groups are distinguished one from the other by pattern design and not by density. Select clear, distinct, contrasting patterns, or colors that will produce a nice-looking map. The boundaries of the patterns are formed in the way described in paragraphs 1 and 2 above.

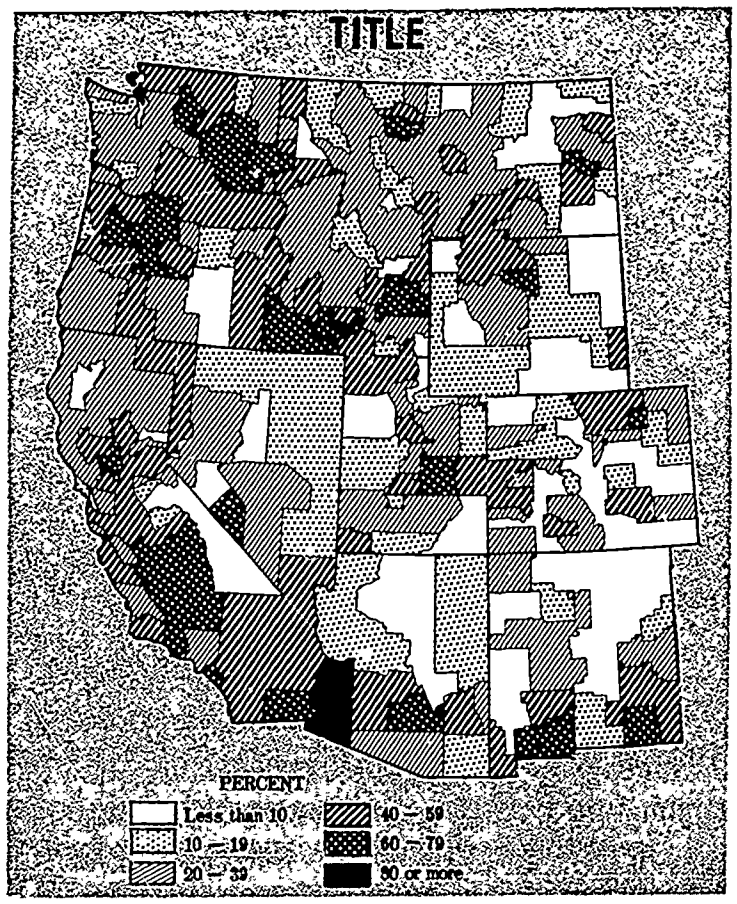


FIGURE 45

Geographic Maps

Although some geographic maps are based on statistics, they differ from the statistical map in that the data are located by latitude and longitude coordinates or related to some geographic

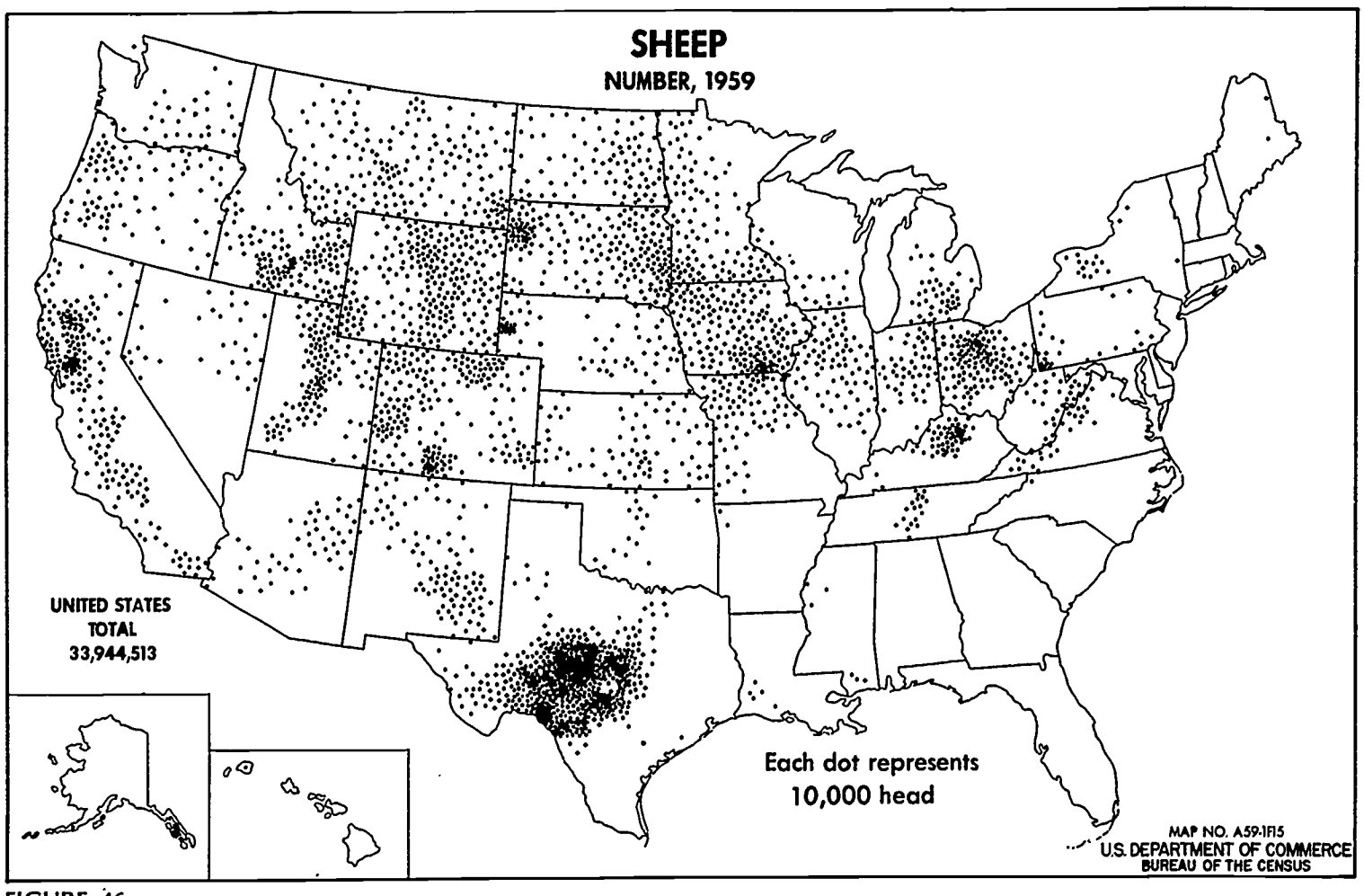


FIGURE 46

feature. Methods that could be used on geographic maps are dots, isoline, and cross-hatching.

Dots may be used for showing amounts by small political units, to present such data as total population of a specific species by land plots. Geographic dot maps show density, significance, and approximate geographic location. The dots are located by relating them to known population distribution, climate, soils, irrigated areas, physical or cultural features, etc.

Important factors that should be considered are the scale of the map, the number of dots, the value of each dot, and the size of each dot. All of these factors are closely related, and a change in any one could affect the physical appearance of the final presentation.

Each dot is made to represent a given quantity, which will, in turn, determine the number of dots. The largest number of dots of a given size that can be fitted in the smallest area will help to determine the value for each dot. If the quantity that each dot represents is made too large, there will be too few dots and a corresponding loss of distribution. Increasing the size of the dot does not always compensate for a smaller number of dots. Conversely, if the quantity is too small, there will be too many dots, and the areas will tend to fill in solid black.

Sometimes the only way to achieve a good correlation between number, value, and size of dots, and scale of the map is by experimenting with a portion of the map. Try out different sizes and numbers of dots in a congested area of the map before deciding on the final value and size. Leroy pens or any round point pen in different sizes may be used for making the dots. Lacking these, take a small round stick, sand it to the right size, dip in ink, and form the dots. A little experimenting will help determine the correct amount of ink and pressure to use.

The small area boundaries used as guides for containing the dots during construction are not usually shown on the final because numerous small boundaries tend to interfere or distort the densities formed by the dots.

Dots, especially in fringe or sparse areas of the map, cannot be interpreted as representing an exact value at a precise location. A dot in the sparse areas may represent scattered areas accumulated to represent the value of one dot. The sparse areas are the weak points of a dot map presentation.

In certain types of dot maps, the dots are actually located by map features. In an area map showing distribution of organisms, for example, dots are placed at the location of the certain numbers of the organisms. The map will show concentration of the organisms. In this instance, the only factors to consider are size of the dot and scale of the map. The value and number of dots are already determined by the type of data.

Isolines on maps, as on Figure 47, show lines of equal value, such as isohyets (lines of equal rainfall); isotherms (lines of equal temperature); and isobars (lines of equal barometric pressure). Isoline maps are excellent for the portrayal and analysis of a large number of observations requiring some form of geographic location. Example—rainfall data for all the weather stations in the United States. The weather stations have to be located by latitude and longitude coordinates. The final presenta-

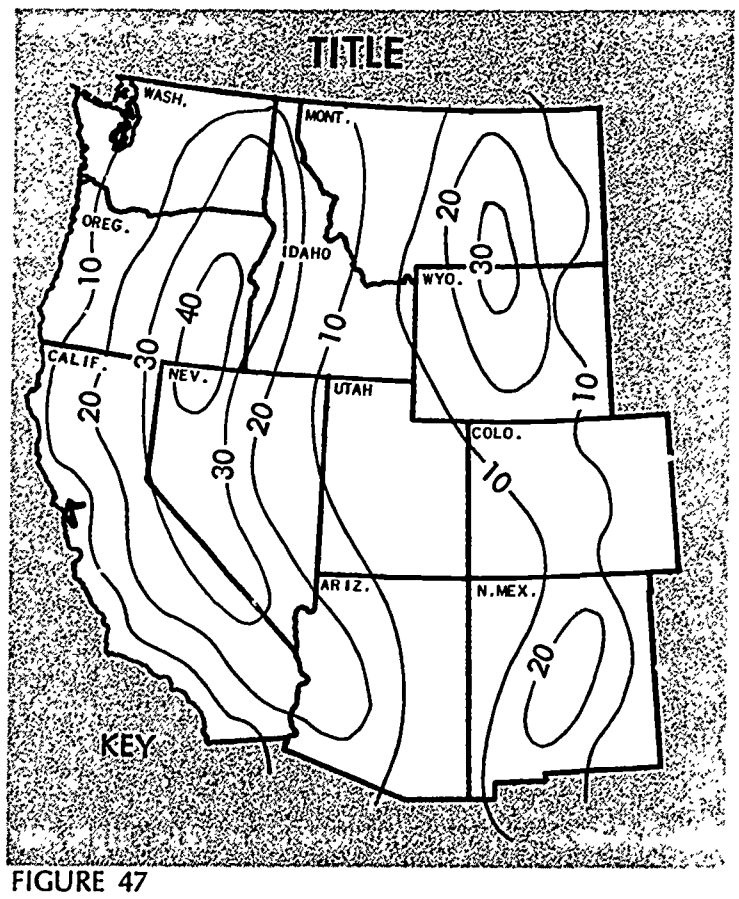


FIGURE 47

tion shows lines of equal value enclosing areas of concentration. The isolines are used to bring order out of a confusion of plotted data scattered over the map.

Data positions, such as rainfall stations, are first located by latitude and longitude coordinates or by cities and towns already located. Data figures are placed near the plotted positions. The values are used to develop the isolines and are not usually shown on the final map.

An appropriate even value interval for the isolines (Example: 10", 20", 30", 40", etc.) is then selected. The first isoline is drawn to include all data of 10 inches and under and to exclude all data over 10 inches, interpolating between values where necessary. The second isoline, 20 inches, is drawn to include all values over 10 inches, up to and including 20. Other isolines are drawn in a similar manner. Separate 10-inch isolines need not be drawn for the complete range of data. There may be a few observations which are not important but are higher than the normal range set for the map. Example—observations of 55, 59, and 69 inches on mountain peaks. If we use the example above of 10, 20, 30, and 40-inch isolines, the cut-off could be made at 40 inches. Thus the last isoline would include all observations over 40 inches.

The final map may be presented either in the form of isolines only, with no shadings, or the area between isolines may be shaded with density crosshatch patterns. (See Figure 48.)

When only isolines are shown, more detail may be included if necessary by drawing additional intermediate isolines. Each isoline should be clearly and properly labeled to show its value.

When crosshatch patterns are used, however, keep the number of isolines to a minimum. Con-

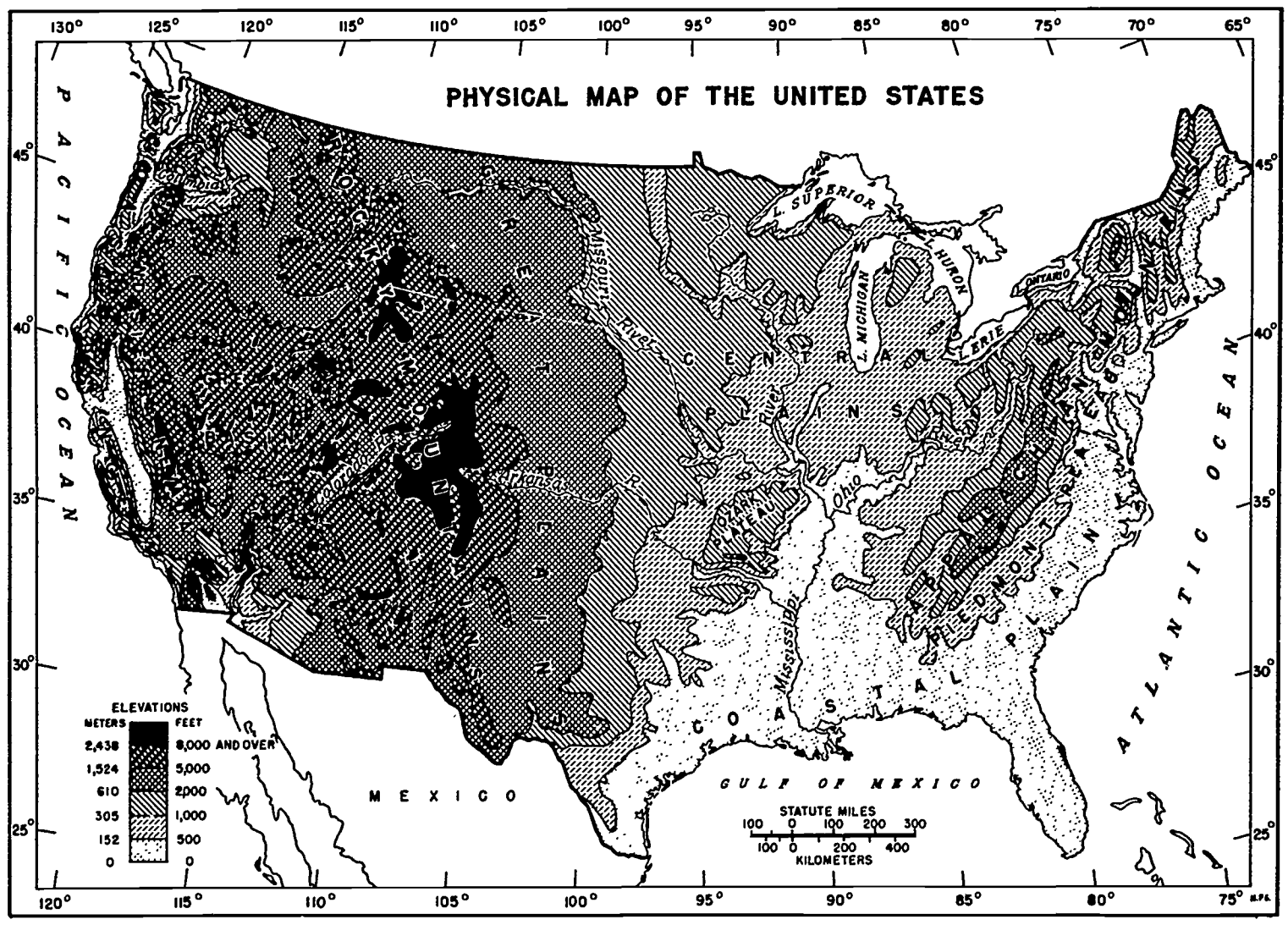


FIGURE 48

struct an appropriate legend to identify the shadings and to show the range of values.

It is important to select a value interval that will produce enough isolines to achieve your objective and also produce a well-balanced, attractive map. To save time, start with a larger value interval, such as 20 inches. If the value proves too large and there are not enough isolines, then go over it again and draw the 10-inch lines.

Crosshatching is used on maps, including crosshatched isoline maps, whose data are located on the map by geographic coordinates or related to geographic features. Examples—soils maps, agricultural regions, etc. Isoline maps and other maps showing values that require crosshatching should use density patterns with an appropriate legend.

When separate areas require crosshatching, as in a soils map, area patterns should be used. The legend should clearly show what each pattern represents. The lettering for the legend should be legible and clear. (See page 9 for details on crosshatch patterns.)

DIAGRAMS

Any type of illustration used to portray nonquantitative forms of data falls into this category. The illustrations may be simple line sketches for emphasizing a statement of facts or a sequence of facts arranged in logical order. Figure 1 is an example of an organization diagram showing the order of graphic presentation. A similar diagram may be used to show genetic line.

Diagrams also include the flow, route, progress, etc., of a technique or procedure, but not quantities. Example—the flow, route, or progress of a scientific procedure at different time intervals. Sketches used to decorate other forms of graphic presentation are also included in this group.

PHOTOGRAPHS

Good clear photographs may be used to illustrate your project. There are a few precautions. Do not use paper clips to hold your photographs; they leave a permanent dent on the face of the photo. Do not write on a paper covering that is placed over a photo to protect it; permanent marks will be left on the photo. Do not use a strong adhesive tape on the face of the photograph, the surface of your only photo could be ruined when removing the tape. Remove any tape slowly and carefully. Select photographs that clearly show only the pertinent facts from the study. Anything additional would detract. If necessary, enlarge a choice section of the photograph to better illustrate the main portion.

Rubber cement may be used to mount pictures. Line up the photo in correct position and fasten gently with two small pieces of tape along one edge. Work the tape back and forth between the fingers to decrease the adhesive qualities. The tape acts as a hinge. Flip the photo over back side up and place a larger scrap of paper under the photo. Make sure the mounting surface is smooth and free of dust, eraser crumbs, etc. Even a small speck under the photo will form a "hill" after mounting. Apply a thin coat of rubber cement to the back of the photo and also to the mounting board. It is important to let both surfaces dry because moist cement trapped between tends to discolor photographic paper. When the cement is dry, flip the photo over and gently burnish in place, then gently remove the tape hinges. The excess dried rubber cement may be removed by rubbing with the fingers or a piece of dried rubber cement. A starter piece of cement may be made by pouring a glob of cement on a glass and letting it dry. When using the piece of cement to remove the excess, start from the edge of the photo and pull outward and away from the edges. Photographs may be removed by inserting a thin spatula under the photo. Use a sawing motion to cut the rubber fibers, then clean both surfaces with the piece of dried cement and start over.

Appropriate photographs representing the subject matter may also be used as a background for a chart or a map. White lines reversed on a photograph are achieved by exposing together a positive film of a chart with a negative of the photo.

TABLES

Tables, though not as graphic in their presentation of data as are charts and illustrations, do nevertheless communicate a quantity of data in a visual form. In a good table, the reader can easily grasp the significance of the data and can study individual entries and compare various items.

Tables should be as compact and clear as possible. Several short tables are preferable to one long or complicated one. The data will be clearer if the quantities to be compared appear in the same column and are arranged in ascending or descending order.

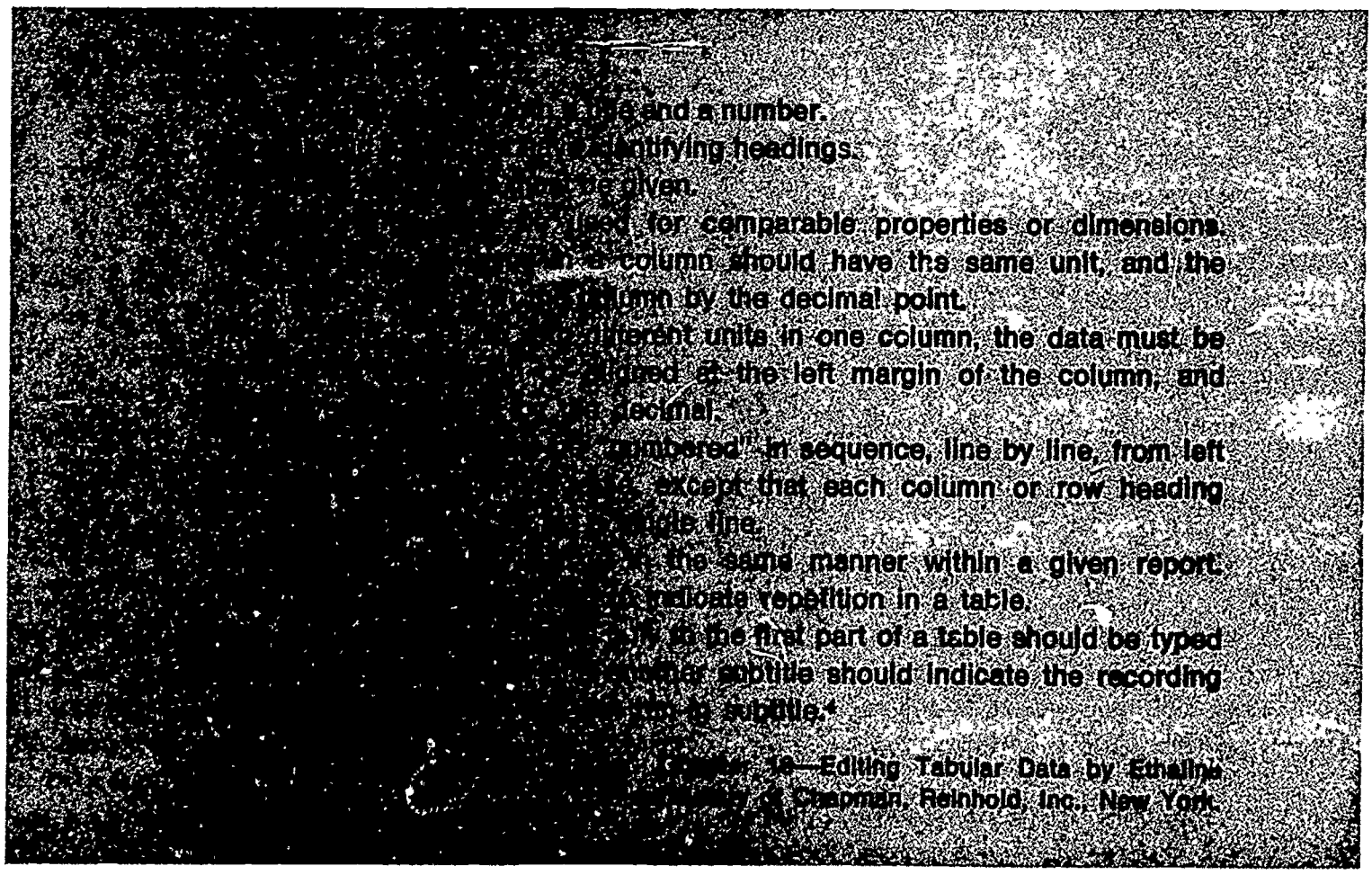
The table must have an appropriate head or title, and each column must have a heading that is an accurate classification for the items or figures beneath it. For example, in the report of an ecology study where one assembled data on numbers of certain plants, certain insects, and perhaps temperature readings at several locations, data on plants should be in one column, on insects in another, and temperature in still another. The table might be arranged as follows:

TABLE 1. POPULATION OF CERTAIN PLANTS AND INSECTS AND 4 P.M. TEMPERATURES IN TWO AREAS[a]

Area Studied	Plants		Insects		Temperature at 4 p.m.
	Clover	Grass	Ants	Grasshoppers	
Plot #1 at stream bank					°C
Plot #2 under oak tree					

[a] Footnote should indicate when study was made.

Excellent discussions of preparation of tables can be found in *Words Into Type, The Chicago Style Manual,* and in *Technical Editing.* The following check list is reproduced from *Technical Editing.*



[illegible] and a number.
[illegible] identifying headings.
[illegible] given.
[illegible] for comparable properties or dimensions.
[illegible] column should have the same unit, and the [illegible] column by the decimal point.
[illegible] different units in one column, the data must be [illegible] at the left margin of the column, and [illegible] decimal.
[illegible] "numbered" in sequence, line by line, from left [illegible] except that each column or row heading [illegible] line.
[illegible] the same manner within a given report.
[illegible] indicate repetition in a table.
[illegible] in the first part of a table should be typed [illegible] subtitle should indicate the recording [illegible] subtitle.[4]

[illegible] 19—Editing Tabular Data by Ethalyne [illegible] Chapman, Reinhold, Inc., New York.

SELECTED GLOSSARY OF TERMS USED IN GRAPHIC PRESENTATION

ABSOLUTE CHART—any chart that shows the actual value of the data.

AMOUNT SCALE—a scale measuring the magnitude of the data plotted on the grid.

ARITHMETIC SCALE—a scale on which equal amounts are represented by equal space intervals.

BASE LINE—any principal line of reference, such as zero, or 100 percent line.

BROKEN SCALE—a scale that does not extend continuously to the principal line of reference or zero.

CHART SCALES—spacing between horizontal and vertical rulings of the grid surface. The value of the spaces is indicated by a figure at the end of the grid rulings.

CLASS INTERVAL—a scale on a frequency chart, usually the horizontal scale, used to indicate the groups according to classification or size.

COMPOSITE BAR—a total bar that is composed of two or more parts.

COORDINATE SURFACE—the area formed by the intersection of a series of horizontal rulings X-axis) with a series of vertical rulings (Y-axis).

CURVE—a line connecting, in order, a series of points to indicate the trend of successive values.

DEPENDENT VARIABLE—the factor of amount associated with each time designation. It is also called the ordinate or Y-axis.

DEPRESSION, VALLEY, TROUGH, MINIMUM, BOTTOM, LOW—these terms are used in referring to the low point of a curve, or series of bars, where a downward movement changes to an upward one.

DESIGNATIONS—labels placed near the curve, bar, or other graphic device for the purpose of identification.

DEVIATION—a movement away from an estimate, a standard, or other reference line.

FLUCTUATION—often used to denote a minor variation, a wave-like movement.

GRID AREA—coordinate surface formed by a network of intersecting lines on which a chart is prepared.

GRID RULINGS—the actual lines forming the grid or coordinate surface.

INCLINE, UPWARD, SLOPE, RISE, CLIMB, JUMP—terms used to indicate varying degrees of movement upward.

INDEPENDENT VARIABLE—the factor of time plotted on the horizontal scale of a time-series chart. Is also called the abscissa or X-axis, key to help remember it: TAXI—*T*ime, *A*bscissa, *X*-axis, *I*ndependent variable. TAXI moves horizontally.

KEY—small separate representation of the graphic device, with label for purpose of identification.

LAG—the time interval between the corresponding movements or phases of two related curves.

LINE OF REFERENCE—any principal grid ruling, such as a zero line, or 100 percent line, made to serve as a base from which values on the chart may be measured.

LOGARITHMIC SCALE—a ratio scale based on logarithms and so arranged that the space intervals represent uniform percentage increases —Example: All 100 percent intervals are equally spaced; likewise, all 25 percent intervals, etc.

MAJOR GRID RULINGS—grid lines that are inked and shown on the final chart.

MOVEMENT—used to describe in general a change of any kind.

OPTICAL ILLUSIONS—unreal or misleading images, a deceptive appearance. Various combinations of lines and angles, crosshatched patterns, are examples of illusions.

PEAK, CREST, MAXIMUM, TOP, HIGH—terms used in referring to the high points of a curve, or series of bars where an upward movement changes to a downward one.

PLOTTING SCALE—a space between the major grid rulings that is subdivided on a separate piece of paper and used for plotting the data values.

POINT—the location of value of a grid or other field in relation to the vertical (Y) and horizontal (X) scales.

RECOVERY—a favorable movement of a curve or series of bars from an unfavorable or less favorable position.

RELATIVE CHART—any chart that shows percentage values. The amount scale reads from 0 to 100 percent.

SCALE RANGE—the space included on a chart between the upper and lower limits of the scale.

SEASONAL VARIATION—annual recurring movement under influences peculiar to a particular portion of the year.

SLOPE—a term used to measure the intensity of the rise or fall of a curve.

STUBS OR TICKS—partial grid rulings inked to extend only short distances into the grid area to show the position of intermediate grid lines that are not shown or completely inked on the final chart.

TIME SCALE—horizontal scales with units of time indicated at the terminal of the vertical rulings (the independent variable).

TITLE—a brief statement of the main subject matter of an illustration.

TREND—the general tendency of a curve, over a period of time, exclusive of minor fluctuations.

VARIATION—generally means a series of fluctuations in opposite directions, as opposed to continuous movement.

VISUALIZATION—the act or power of forming visual images, or mental pictures of objects not present to the senses.

2 TOOLS AND TECHNIQUES

by
Kenneth B. Frye
Chief, Art Section, Publications Division
National Education Association

TOOLS AND TECHNIQUES

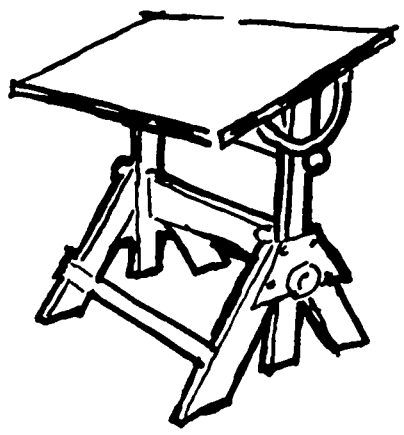
The previous section describes the presentation of data in graphic format. This section will deal with techniques and thus with the tools of the trade. Students and other nonprofessionals can quickly improve the appearance of graphs and other illustrations by making use of some of the specialized equipment used by professional artists and draftsmen. Schools and many offices where reports originate may find it worth while to invest in some of the major pieces of equipment found in art studios.

The first step is to become familiar with the tools themselves and then study their uses as described in the following pages and in more detail in books listed in the Bibliography.

The following list includes the most useful tools for use in preparing graphic illustrations for scientific and technical reports. They can be purchased from any art supply store and from many stationery or office supply stores. They range from simple pencils for individual use to professional items that would serve many students in a school. The prices given are approximate to give the prospective purchaser an idea of cost of the various items. Most students would probably use items marked * often enough to suggest individual purchase.[1]

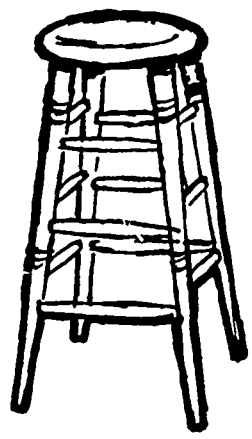
[1] Prices given are only approximate. Check prices at your local art or stationery shop or in the catalogs of companies supplying these items.

ART TABLE
31"x42"
$40



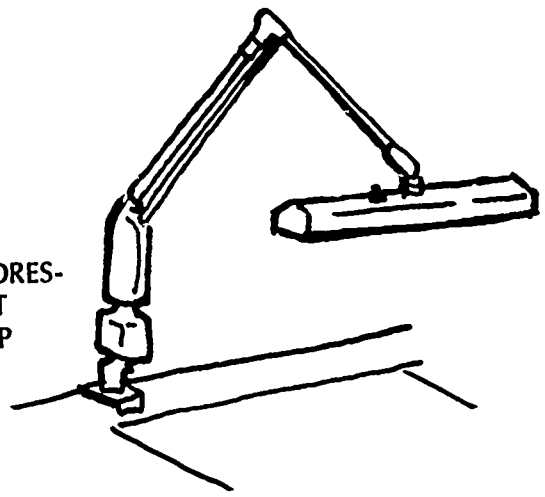
This table can tilt from flat to vertical very easily and has a soft, smooth, basswood top for easy thumbtacking.

STOOL
27" high x
17" sq.
$5



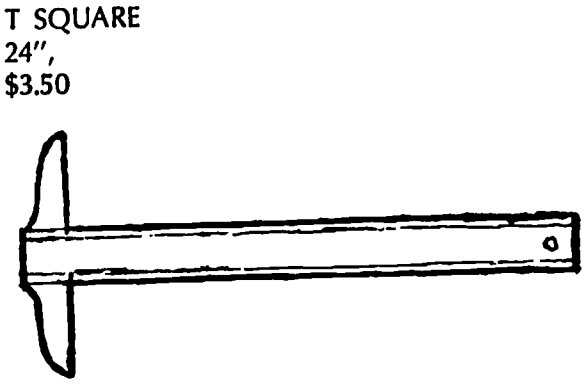
A sturdy, functional stool for use at an art table.

FLUORES-
CENT
LAMP
$28



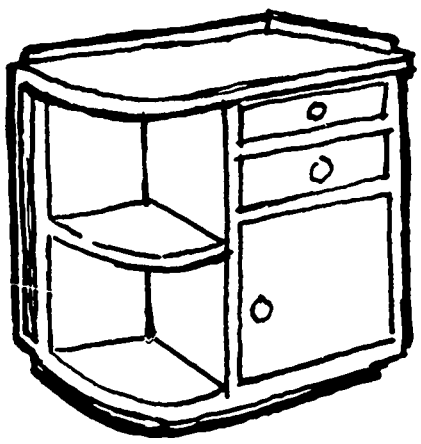
This two-bulb lamp gives soft, balanced light wherever it is needed.

*T SQUARE
24",
$3.50



This drafting tool slides along the left hand edge of the table or board. It is used to assure parallel horizontal lines. A triangle can be used against it to assure parallel verticals.

TABORET
27" high x
17" sq.
$35

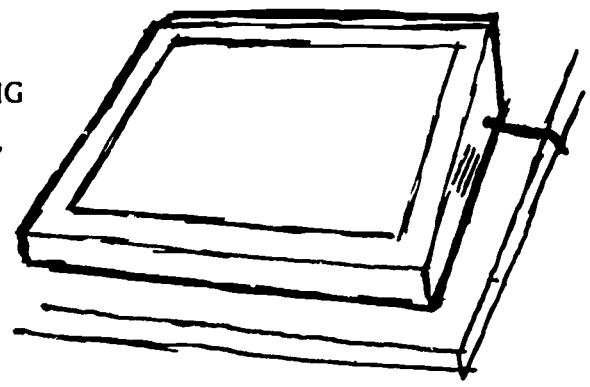


This is an artist's work table and tool chest to use as a caddy for all sorts of supplies.

*45° TRIANGLE
8"—$1
12"—$2

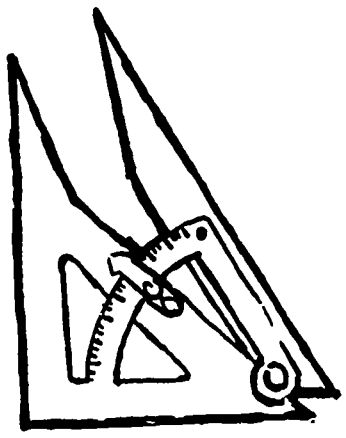
30°/60°
TRIANGLE
8"—$ .70
12"—$1.50

TRACING
BOX
16"x20"
$35



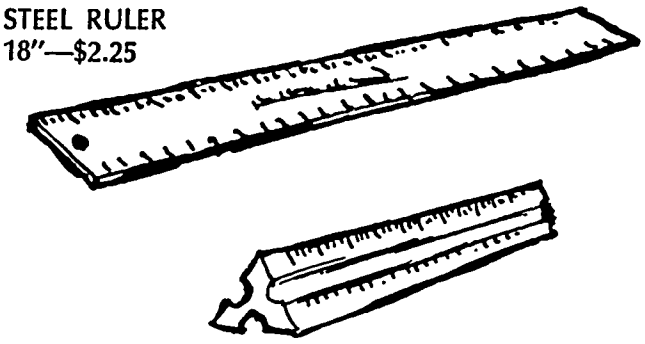
This box has frosted glass on top and either incandescent or fluorescent bulbs inside. This makes it easy to see through thin paper to trace.

ADJUSTABLE
TRIANGLE
8"—$3
12"—$5



These three tools can be used in conjunction with the T square to perform almost all line work in your chart.

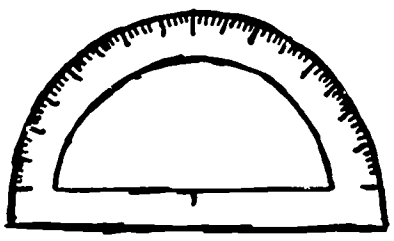
*STEEL RULER
18"—$2.25



WOODEN SCALE
12"—$1 - $3

A calibrated steel rule is excellent for maintaining a straight, unwarped edge. It can be used as a guide for cutting. A scale is a multifaced ruler that has proportional scales such as 1/32, 1/8, 3/8, 1-1/2, and 3. This is useful in proportioning any figure.

PROTRACTOR
6"
$1

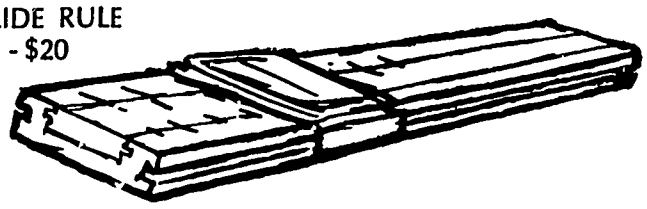


This plastic device is a tool calibrated in both directions to break up a semicircle into degrees and minutes.

*FRENCH
CURVE
$1.50 - $10

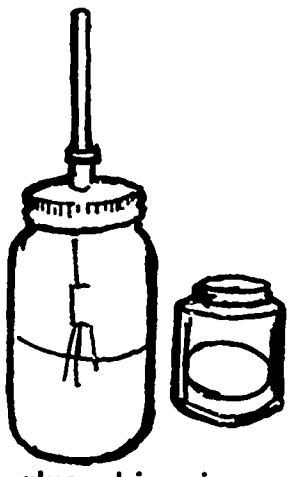
This plastic device can be manipulated to smooth out any curve in a chart or illustration.

*SLIDE RULE
$1 - $20



No student should leave school without a thorough knowledge of how to proportion, multiply and divide on a slide rule no matter what field he wishes to pursue.

*RUBBER
CEMENT
½ pint
$1.50

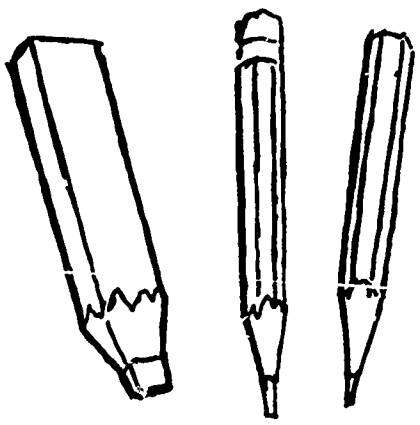


This familiar glue dries in seconds, will not wrinkle paper, and can be removed at any time with Bestine solvent or rubbed off.

*SPEED-BALL
PEN
holder $0.20
points $0.50
india ink
¾ oz. $0.35

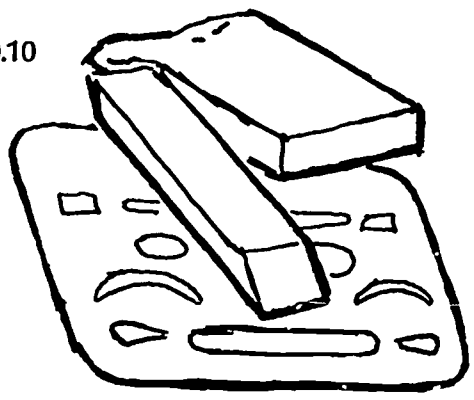
A wide variety of square and rounded points permits an endless variety of lettering possibilities as well as quick and consistent bar graphs and other illustrations.

*PENCILS
(2B)
chisel point $0.20
(4B)
carpenter's $0.40
standard $0.20
(9H-6B)
colored $0.20
sand pad $0.10



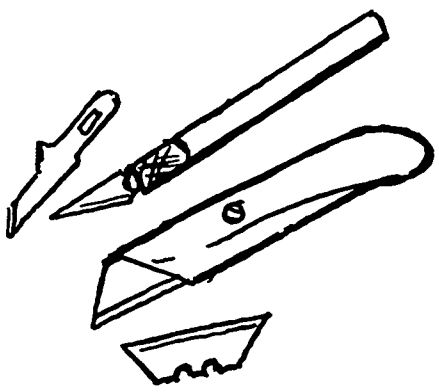
While pencils are very standard, many students do not know the variety or use of them. Standard pencils are graded from 9H (very hard) through HB (regular) to 6B (very soft). The chisel point (⅛") and the carpenter's (⅜") pencils are useful for basic layouts and even finished charts for less important reports. Be sure to fix pencil drawings for permanent use.

*ERASERS
kneadable $0.10
ruby $0.10
guide $0.20



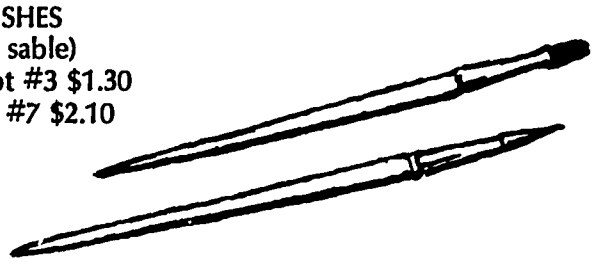
We all make mistakes, and when we do the proper eraser properly used is a must. The kneadable eraser can be manipulated like clay to any shape. Like wallpaper cleaner, it absorbs dirt and doesn't crumble. For tough jobs the ruby eraser can be used. A metal erasing guide with small cutouts can help in being selective in removal.

*KNIVES
mat—$1.50
stencil—$0.35



For cutting cardboard or other heavy boards, the mat knife is the best tool to use. Always use a metal straight edge and watch out for the fingers. Stencil or frisket knives are smaller versions used for cutting out the various acetates mentioned above as well as thin paper, models, etc. Both types have replaceable blades.

*BRUSHES
(red sable)
script #3 $1.30
sign #7 $2.10



Fine details and broad effects can be achieved only with a good brush. Here quality counts. Russian red sable is the only type to consider. Others will not be satisfactory.

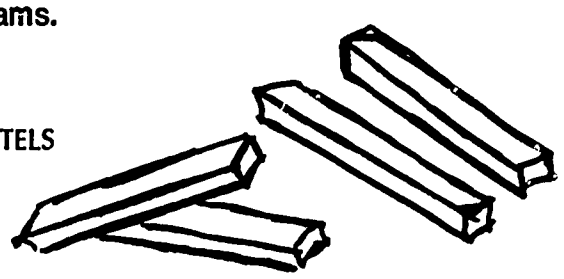
WORKABLE
FIXATIF
Aerosol
20 oz.—$1.95

This is a most useful item to seal in pencil and water color illustration both for protection and over-working.

DESIGNERS'
WATER
COLORS
12 one-oz.
jars—$5
(also in tubes
and pans)

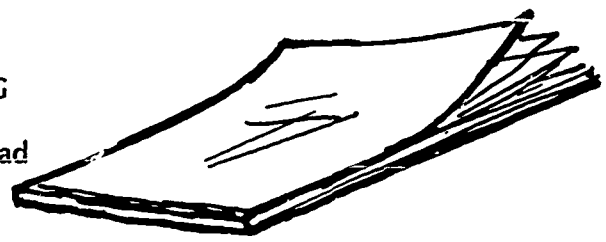
Finer ground than poster colors, these opaque colors can be used straight from the jar or thinned for use in wash. Very good for illustration diagrams.

HARD PASTELS
Set of 12
$2



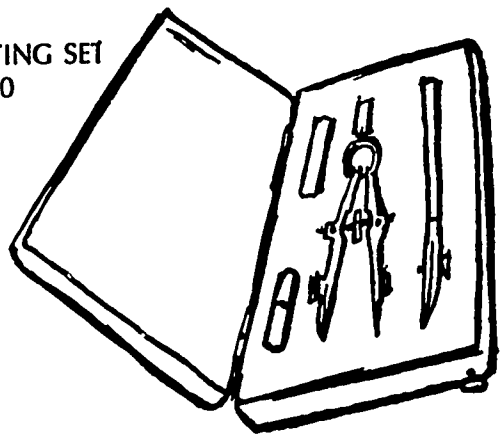
Good for quick layouts and useful for finished work if heavily "fixed" with a plastic or shellac spray to prevent smudging.

*TRACING
PAPER
9"x12" pad
$0.65



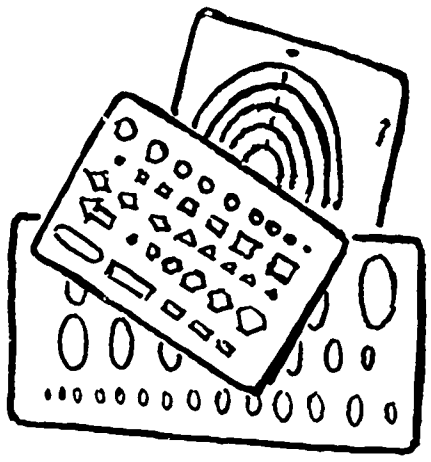
The see-through quality of this paper makes it easy to organize materials from a number of sources onto one sheet. Corrections are easily made, and items can readily be moved about.

DRAFTING SET
$7 - $50



Anyone setting out to do careful mechanical drawing of any kind needs a set of tools designed for the purpose. Sets should contain a ruling pen, pen and pencil, compass, and dividers.

TEMPLATES
Drafting
Architecture
Chemical
Circular
Ellipse
$1 - $3



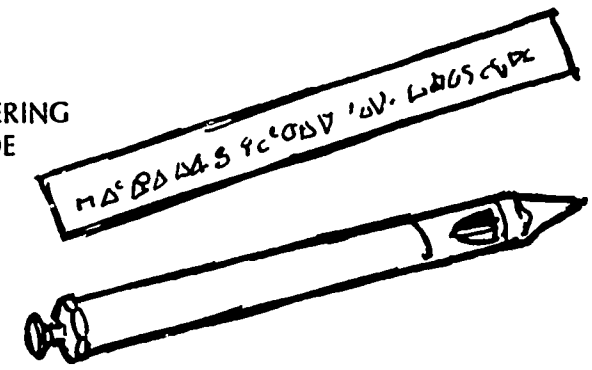
Triangles, bolts, beakers, curves, letters, etc., can be traced through appropriate guides cut through 1/8" clear plastic.

*RULING PEN
$2 - $5

This pen can be adjusted by a thumb screw to draw a consistent line of a variety of widths. It is inked with a dropper from the side.

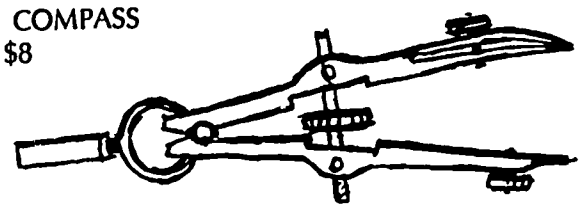
*LETTERING GUIDE
$1.50

*PEN
$2.25



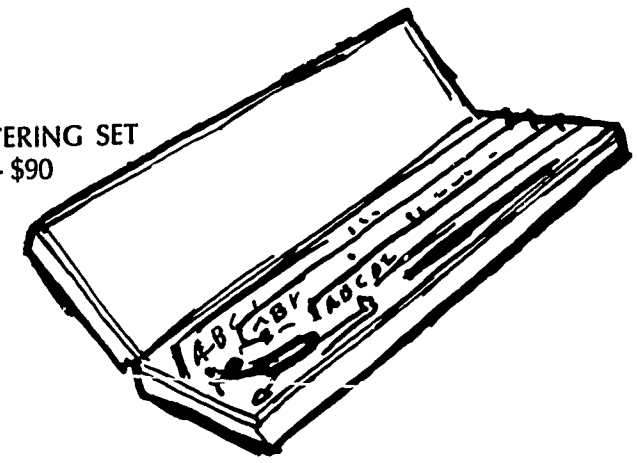
This plastic guide can be slid along a T square as each letter is scribed to form a smooth line of lettering. A special pen with a pin valve is desirable for this purpose, for it feeds easily, glides well, and doesn't flood easily.

*PEN COMPASS
$3 - $8

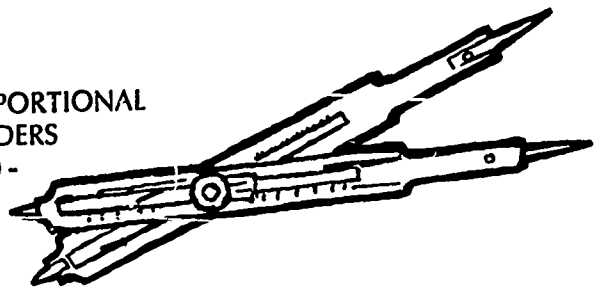


Circles can be set and the desired width of line maintained as in the ruling pen. Most such compasses have alternate attachments for pencil lead.

LETTERING SET
$45 - $90



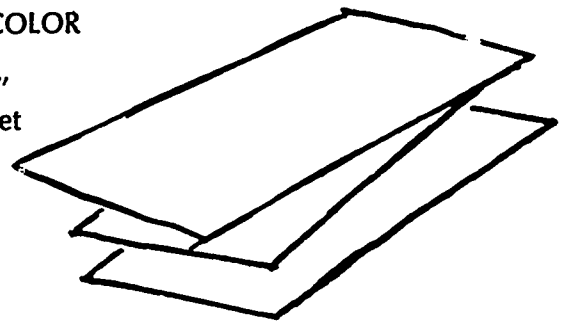
PROPORTIONAL DIVIDERS
$9.50 - $30



These dividers can be adjusted to break any line into almost any given number of equal parts or proportion.

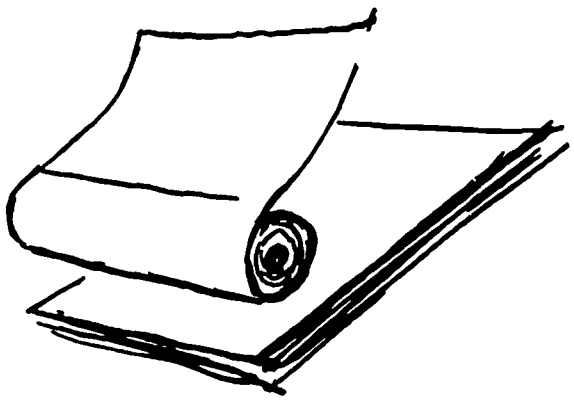
A great variety of points and templates are available for persons or schools who wish to invest in more sophisticated equipment. Pantograph devices can be attached to some sets to slant or distort standard template faces.

WATER COLOR
PAPER
17½"x22"
$0.25 sheet
70 lb.



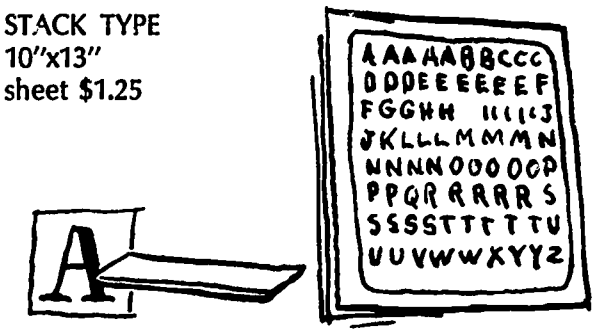
The best is 100% rag content. It comes in three surfaces: rough, coldpress (medium), and hot press (smooth). For most purposes the cold press is best. The paper will accept pen, pencil, water, wash, etc., and is very suitable for illustrations where mild tones are desirable.

CLEAR
ACETATE
25 sheets
9"x12"x.003
$1.80—also
in rolls



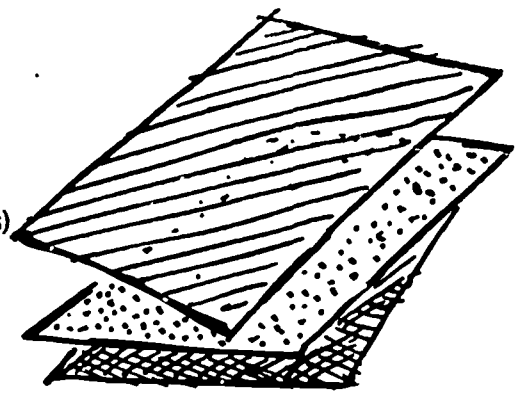
This cellophane-clear stock permits removable overlays where this is desirable to show component parts (i.e., a graph or parts of a flower).

STACK TYPE
10"x13"
sheet $1.25



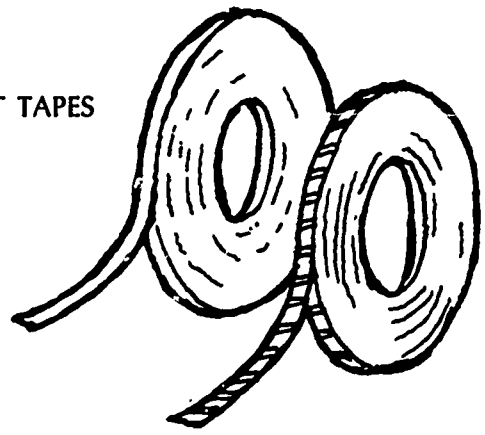
Complete alphabets in many styles and sizes are available on wax-backed acetate. These can be cut out with a razor or knife, removed from the backing sheet, placed in position and then rubbed to adhere to the art work. There is another form of stack type in which the letter image is printed on the wax side of the sheet so that only the letter image comes off when the sheet is burnished.

SHADING
SHEETS
(wax-
backed
tones
and colors)



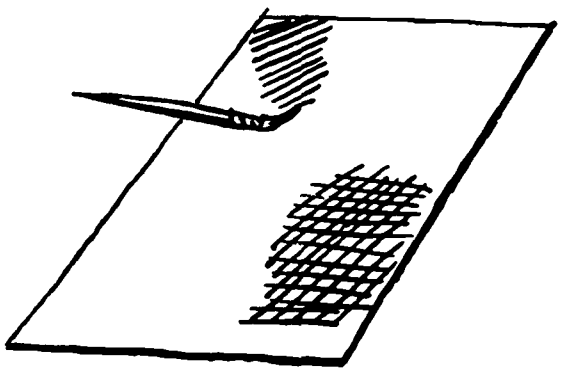
Tones, colors, textures, type, numbers, etc., are available printed on cel sheets with wax backing. They can be cut out with a single edged razor blade, placed into position, and rubbed or burnished to fix them.

*CHART TAPES



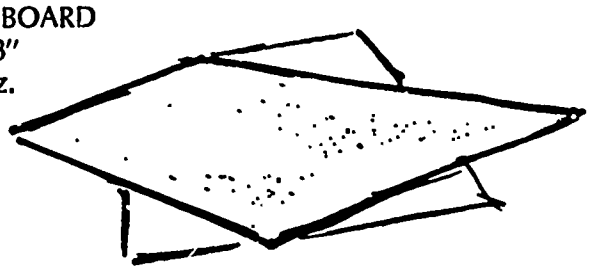
These are opaque, transparent, or patterned tapes with an adhesive back and are available in various widths.

DOUBLE-
TONE
17½"x
24"x1/32"
$2.20



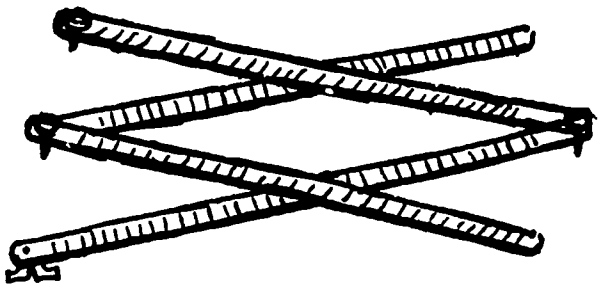
This plain white board can develop line patterns when painted with either of two water-clear developers. One develops a line pattern and the other a crosshatched pattern.

ROSS BOARD
22"x28"
$5 doz.



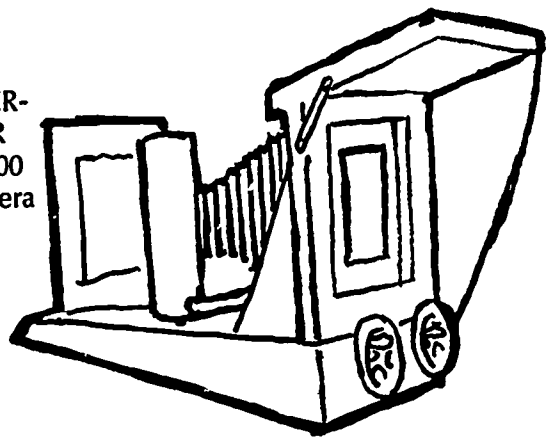
This 1/16" thick board has a rough surface and comes in a variety of textures. It has a thin clay surface which can be scratched through after an ink drawing has been done on it. A black grease pencil can be used to bring out the texture for gray areas.

PANTOGRAPH
$4 - $15



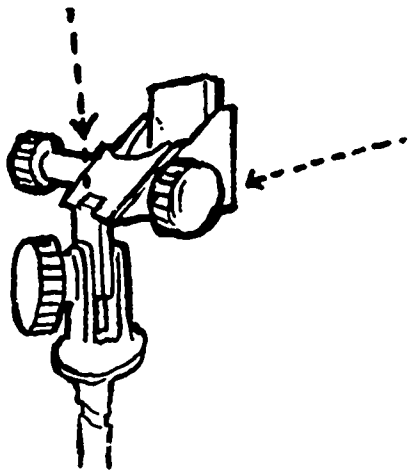
This device is calibrated to enlarge or reduce by tracing a drawing with a pointer on one end while a pencil on another arm of the device draws the item in the desired size.

ENLARGER-
REDUCER
$270 - $500
plus camera
options



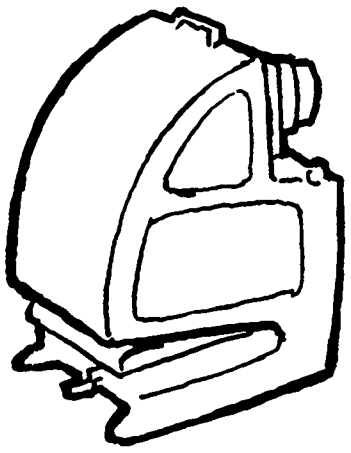
The school system could well afford to invest in this device. A number of forms of "Lucy" are available, and most are equipped to handle flat or 3-dimensional copy up to 2 feet square and enlarge up to 2-3 times and reduce 4-5 times in one operation. These can be used as cameras or enlargers with addition of a pressure back at a modest cost.

CAMERA-
LUCIDA
$75



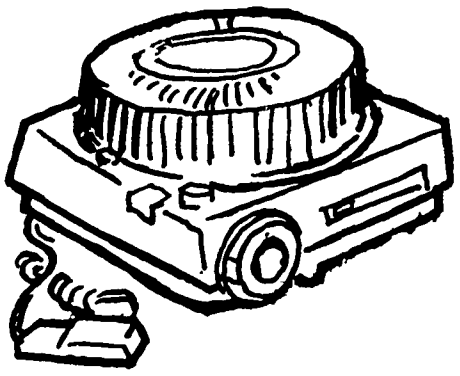
This device utilizes the effect of split image to enlarge or reduce in any proportion. This is a very portable and adaptable tool. The user views an object through a lens that *seems* to project the image on a paper below. The viewer then traces the *ghost* image.

OPAQUE
PROJECTOR
$70 - $500



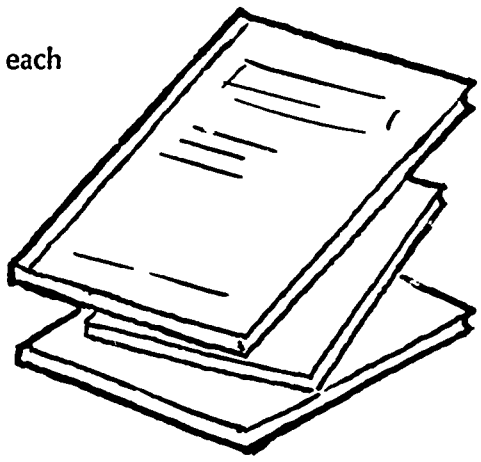
Any flat opaque sheet can be enlarged by this device to any desired size. It can also be used by the teacher or student for lecture or demonstration.

SLIDE-
PROJECTOR
$20



This is another school purchase. Most schools have several in stock, but an inexpensive single slide model for student use is very useful in drawing technical objects of greatly changed size.

BOOKS
lettering $1 each
perspective
painting
color
symbology
etc.



A complete library of technical books in all areas of graphic and fine arts can be purchased for a very small sum in paper back. These are readily available in art supply or book stores. How-to-do-it books are simple enough to be easily read.

LAYOUT

Generally speaking if a device works well it will look well. This means that the presenter has used the best type of device with which to present his material. He has selected the graph paper best suited to the scale and dimensions of his presentation. He has plotted his lines or columns, etc., to fill the space allotted and has plotted in such a way as to give a crystal-clear illustration of the comparisons intended with no chance of misinterpretation. He has allowed a maximum of area for the comparison range so that the comparison will be clear. He has maintained a balance between the void or white space and the areas treated with black, color, or shade. Plenty of white space has been left around the illustration. The title, caption, key, and labels have been positioned in such a way as to permit maximum legibility, design balance, and unmistakable identity as to function.

To use illustrations which are available but are the wrong size for the report requires some form of enlarging or reducing the illustration. Photographs or photostats can be used, but they are expensive and often are not incisive enough to do the proper job of communication. If this is the case the material can be enlarged or reduced by means of the opaque projector, the slide projector, or the overhead projector. The image can be traced on a piece of paper fastened to the wall or board. A very useful device for this purpose is the camera Lucida. This is a prism (exchangeable for various proportions) affixed to an adjustable metal arm. The principle is that of split vision. The object is viewed through the prism and also the same image *appears* to be projected in the desired size on the copy paper. The student then traces the image as it *seems* to appear. This device is inexpensive, light, portable, and requires no electric power. It is really much simpler than it might sound. It is a capital item like a projector and should be purchased by the school or office. The art department could also make good use of it.

A number of hand devices should be used by the student in the initial layout of the illustrations on the page before bulky or highly technical equipment is brought in. All students should become facile with the use of a slide rule to proportion figures to the page and to convert raw facts to lengths and volumes for graphic presentation. Proportional dividers are very valuable for converting an off-size figure to the assigned space. This device is basically two metal arms with points on both ends. They are fastened together by an adjustable bolt which can be moved up and down within a groove in the arms. The arms are calibrated in such a way that when set the points at one end will span a distance 2, 3, 4, etc., times the distance spanned by the points on the other end. By setting the finder at any given proportion the dividers can very quickly and accurately transpose elements from copy to report. This device is a most versatile one, and the student is urged to purchase one if he can afford the $20 to $30 price. It is a lifelong tool of inestimable value.

LETTERING

All lettering guides are based on the idea of tracing letters on or through a guide. The simplest form is that of using a set of varying sizes of letters cut out of strips of plastic. A pen point of appropriate size is placed in the cut grooves and the template is moved as the various letters are made. More sophisticated devices such as the Leroy set allow some distortion of letters by the pantograph principle. The tracing is done over a template but the actual lettering is done by a robot pen somewhat to the side. This type of lettering is very versatile and highly professional.

Very large and very unique lettering can be done with alphabets printed on sheets of wax-back acetate. In this instance the backing sheet is peeled off, and the letter is positioned in the proper place, cut out, and then burnished. The letter also could be cut to (but not through) the backing sheet and then peeled off, positioned, and burnished. A variation on this is a sheet which has the letter on the wax side. In this case the letter is positioned while still on the master sheet. The letter is then burnished from on top of the master sheet once the letter comes off. The result looks just like fine typography. Dozens of alphabets in various sizes as well as numbers, symbols, Greek letters, dot and line patterns, etc., are available on acetate. A school would do well to keep a large variety of these sheets on hand for student work inasmuch as it is cumbersome and wasteful for a student to order special sheets for his own project. The lettering devices mentioned above are also school purchase items and might be shared with several other departments such as drafting, mathematics, art, etc.

The typewriter can be used on charts to label items of subordinate nature where there is a fairly large quantity and several ranges of hand lettering supersede it on the chart. The chart description, number, and references and credits can most often be typed in. Be sure to draw up the entire page accurately but lightly before the typing or lettering is started. Put down acetates, water color, and drawings after the typing is done.

RULING

Accurate and incisive rules are a requirement for any meaningful chart or illustration. The need for care and exactness at this stage cannot be emphasized too much. Careless rendering gives an air of inaccuracy even if the figure is correct.

Before you render a chart be sure that you have drawn it up carefully in a 4H pencil. Make the outlines optically heavier than interior lines. Make the outlines of bars and all other charting devices heavier than the interior lines. Always use a triangle or ruler as a guide.

Fill the ruling pen half full of india ink with a dropper. Hold the pen point against the ruler pointed out at a slight angle to prevent the ink from flowing under the ruler. Always be sure to have enough ink in the pen to complete the line. Always use a test paper to check for line width and under or over ink supply. Be sure ink is dry before placing the ruler on the paper for subsequent lines. Several new types of pens with varying widths of pin-valve nibs or points are available but are more costly and require many nibs to get the proper variety. Cleaning these small nibs is another drawback for ,the novice with limited need.

French or ship curves are available for control of curve charts, and ink compasses can draw circles of varying diameter and thickness. These use the same type of point as the standard ruling pen.

Various widths of rules are available on wax-backed acetate. These are applied in the same manner as are the alphabets mentioned earlier. The rule should be cut with a stencil knife held on the edge of a metal ruler. The acetate should be cut through to the base, lifted off, placed in the proper place, and then burnished. A number of gum-backed tapes of varying weights and colors are available for curves as well as straight lines. It is a good idea to place a sheet of tracing paper over these tapes before burnishing, or the tape might have a tendency to move.

SHADING DEVICES

When a number of items are being compared in a bar graph or other type of cumulative graph there is a need to make the various areas of comparison clearly separable and identifiable with a key. To do this consistent colors or line-tone patterns are used. Line patterns blend better with most reports than color which is not used throughout. Such patterns can be achieved by stippling or crosshatching with a pen. A much wider variety of patterns can be obtained from the various wax-backed-acetate sheets available at art supply stores. These sheets can be cut and fit as described earlier when used for lettering and rules. The patterns are consistent, varied in texture and value, and lend themselves well to keying. There are a number of other mechanical devices to achieve this line-pattern result, depending on the exact results needed. One approach is to select one of a series of specially embossed boards or papers. The regular-rough texture yields an even pattern by stroking over it evenly with a black wax pencil or chalk. A three-dimensional quality can be achieved with this technique if this is desirable. It lends itself very well to many drawings of a semi-freehand nature where realism is desired. These drawings can be easily blueprinted or photographed. This technique lacks versatility for graphs in which many separable areas are involved, because only one pattern is possible per sheet.

Another technique allows for two tones plus black and white. A specially prepared white sheet is painted with a perfectly clear developer. The areas which are painted almost instantly create a clean black line pattern where the developer touches. One developer brings out a light pattern and the other brings out a dark crosshatched pattern. Fine detail can be achieved in this manner.

REPRODUCTION

It is often desirable to duplicate an element or an entire report. Many means of doing this are available, but we will deal here with a few popular types in each quantity category. The quantities described are only rough approximations for the sake of easy description.

ONE TO 100. When very small quantities are desired, the simplest technique is the photocopy (Xerox or other method) or the photostat. Xerox copies are highly satisfactory reproductions of typed copy or line drawings, and even photographs are recognizable but usually are not very clear. The photostat is a photograph made directly on paper, and thus the black marks on the copy appear white and vice versa. Enlargements and reductions are possible, and a stat of the stat will bring the black image back to match the black on the copy. Photostats reproduce *only* line copy. Blueprints, brownprints, and a number of diazole dye products are less expensive methods of reproducing the image same size, again in reverse color. Some diazole products reproduce black for black, but are a bit more expensive. These ammonia-developed products can be made by the student *without* use of a dark room. Photographs can reproduce lines and all ranges of tone accurately in any size—but at a much higher cost.

100-1000. Often it is desirable to reproduce an entire report or a portion of it for quantity distribution. When this is required some form of printing plate and duplicating machine are required. All students are familiar with the mimeograph machine. To prepare a plate for this the basic copy is typed and the figures are traced off on stencil, using a light box and with a dull stylus provided by the manufacturer.

A multilith requires that the basic copy be typed on a special chemically treated plate with a special ribbon. Drawing and lettering can be done with a manufacturer's pencil. These methods allow for no change in size and no tone work.

1000-up. Although larger runs will not concern the student as yet, it would be useful to explore the possibilities of mass printing media. There are four basic means of reproduction which account for 99+% of all mass printing. These are letter press, lithography (offset), silk screen, and gravure (intaglio).

- *Letterpress*

  Letterpress is printing from a raised image, such as type or engravings. The raised portion receives ink, which it then transmits to paper which is pressed against it.

- *Lithography* (offset)

  In this process any black image, such as type proofs or typewriter copy, is photographed, and the negative is contact-printed to a thin chemically treated plate. The plate is then developed and wrapped around a cylinder on a printing press. The plate receives ink only in "exposed" areas. Photographs or other toned materials can be changed to a series of very tiny dots of varying size so that the plate can reproduce the image in what appears to be continuous tone. Lithography is practical for large quantities of typed reports.

- *Silk Screen*

  This is basically a stencil device. A thin sheet of silk or plastic cloth is stretched on a wooden frame. Areas which are not intended to be inked are blocked out in some manner. The plate (or screen) is then placed over the paper and the ink is pressed through the open areas by means of a squeegee. This is a very practical technique for many uses.

- *Gravure* (intaglio)

  In intaglio printing, a metal plate is scratched or acid-etched so that areas which are to print are recessed. Ink is applied to the plate and then rubbed off so that only the recessed areas are inked. Paper is then pressed onto the plate and the ink is "sucked" up to form the image on the paper. Etchings and engravings are printed this way.

SUMMARY

The foremost consideration in the manner of presentation in any report is that it communicate. Anything that does not add to the clarity of the presentation is superfluous. A picture (or chart) may well be worth the proverbial thousand words, or it may confuse so badly that well over a thousand words are needed to clear it up! The following are a few guides to planning:

A. NEED—A graphic presentation is only of value if it serves the purpose better than do words or figures.

B. FORM—Decide on the type of comparisons or relationships deemed most critical and select the form best suited for this purpose. Remember that *text* is best suited for explaining, interpreting, and evaluating. *Tables* are especially good for providing multiple comparison and providing supporting evidence. *Graphic* illustrations and charts are excellent for emphasizing, demonstrating difference, and providing a change of pace.

C. DESIGN—Be sure that the scale selected is used to its fullest in the presentation of material. Be sure to have a clear heading, reference number, clearly identified scale indications, and such footnotes as are needed to explain and give credit.

D. MATERIALS—Do *nothing* freehand if you can possibly help it. Scaling devices, projectors, lettering devices, screening sheets, and a host of hand tools should be used to keep the charts clean and professional looking. People put great faith in charts, so help them get information quickly. Be direct, be simple, be clear, and be accurate.

E. ORGANIZATION—When the written copy is ready and all of the illustrative materials have been prepared, the final step is to arrange them in a logical and harmonious order. Begin with an attractive title page and close with the references or bibliography. Place all illustrative materials as close as possible to the point in the text where they are mentioned or discussed. If these materials are on separate sheets of paper, insert them following the page where the chart or table is mentioned. Thus, the story unfolds in a logical manner and communicates your message to the reader.

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