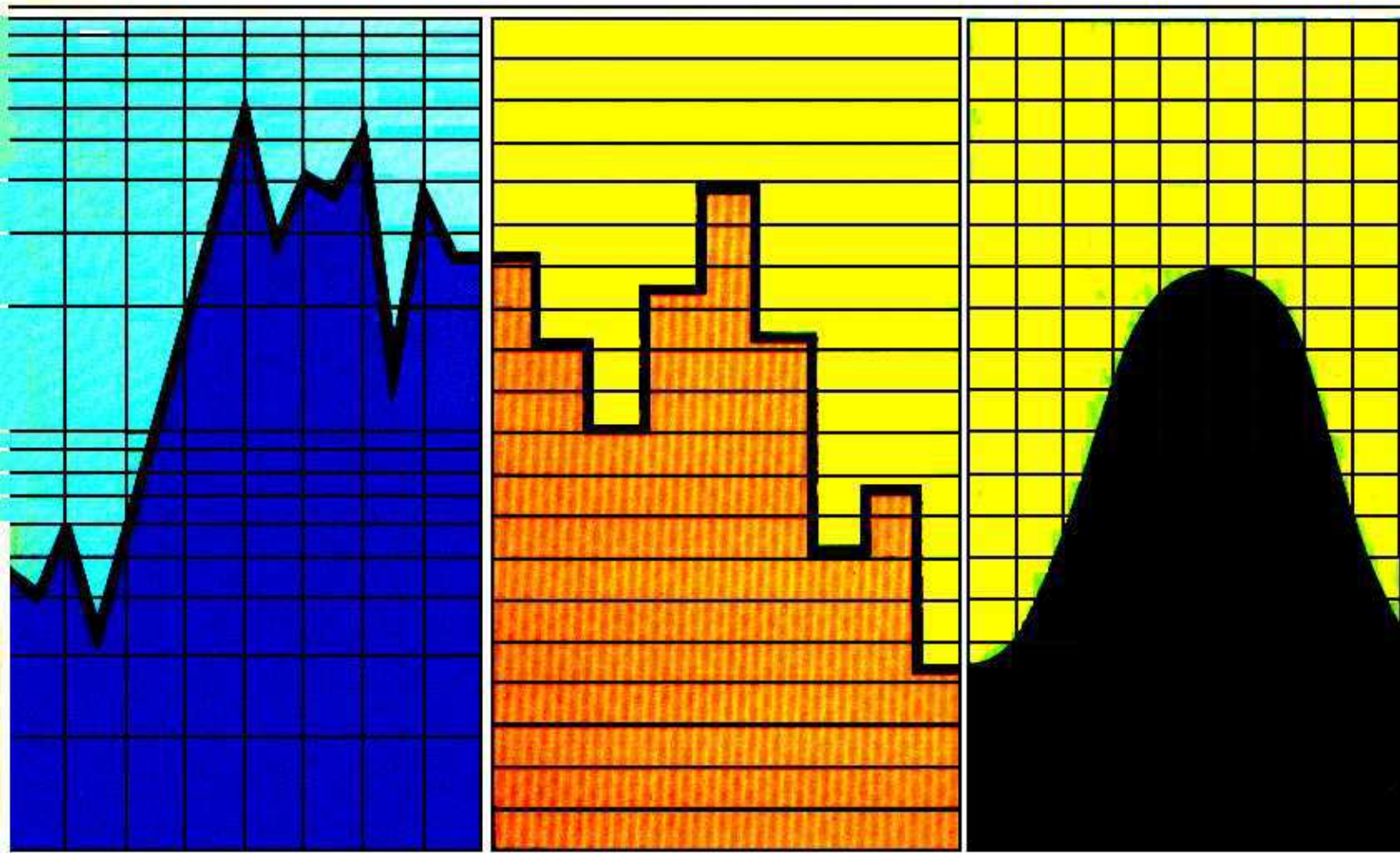


GRAPH PAPER

From Your COPIER



by John S. Craver

Contains 204 graphs of 11 different kinds. Ready to copy whenever you need them. How to draw effective graphs. Forms for scheduling and data collection.

GRAPH PAPER

From Your COPIER

John S. Craver

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How To Copy Graphs

The difference between a page of numbers and a graph is ten minutes of explanation.

A table of numbers is hard to analyze. You can see the large ones, the small ones and whether they increase or decrease, but only a graph can quickly show percentage relationships, trends, seasonal variations, geographic distribution and areas of concentration.

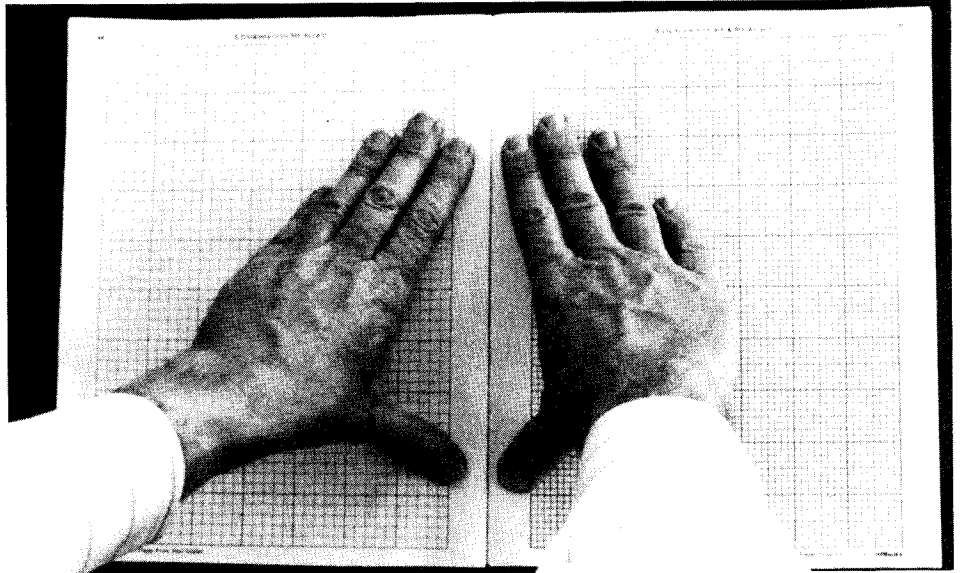
This book contains 204 different graphs of 11 different types and tells you how to use some of them in business and scientific applications, as well as at home and in your artistic endeavors. The data-collection tables are extremely helpful for scheduling. You can copy any of these graphs on your copying machine.

This book explains how to draw and use graphs. Simplified mathematical and statistical explanations are used to explain graph construction.

HOW TO USE THIS BOOK

Most copying machines have a platen or cover which can be raised out of the way to allow copying magazines or books while you hold the pages flat against the copier. To make distortion-free copies, hold the page you want to copy absolutely flat against the glass copy area of your copying machine. This may require "breaking" the binding of this book so the entire page can lay flat against the copy area.

If you can't hold the graph flat enough, or if you want to use the page as your master graph, tear out the page very carefully. Or cut



Before copying graphs from the middle of the book, you may have to break the binding so it opens completely.

it out with a razor blade or sharp knife, being careful to cut only through the desired page. Replace the page when you have finished so it will be there the next time you need to copy that graph.

If your copier requires inserting individual sheets or pages, you must remove the page as I just described.

HOW TO MAKE MASTERS

First copy the graph, add the title, scales and other necessary markings to the copy. This becomes your *master* graph. Make copies of this master and use them to prepare your graphs. If you

make an error in preparing a graph, make additional copies of the master and start over.

While it is easier to copy the graph from the book and use that first-generation copy to create a labelled master to make additional copies, you may prefer to remove the original page from the book, add labels and use it for your master. This will give somewhat darker lines on your copies.

When you are using log-type graphs with very close spacing between some lines, use the book page as the master to provide graph copies with better definition in the fine-line areas.

SAME-SIZE COPIES

Most copying machines produce copies the same size as the original, but some make slightly reduced or enlarged copies. The size change is usually not noticeable and is less than 1/4 of 1% per generation. It is important to know that you may get a reduced or enlarged copy if you are preparing architectural drawings using a scale. You could waste hours plotting measurements with the scale on a grid with dimensions slightly different than you thought they were.

At times it is necessary to copy points from one graph to another by measuring and copying their positions with a pair of dividers. Or, you may place one graph over another on a light table and trace the points. When you do this the grids must be exactly the same size. This can be checked by superimposing one graph over another and holding them up to a strong light to see if the lines match.

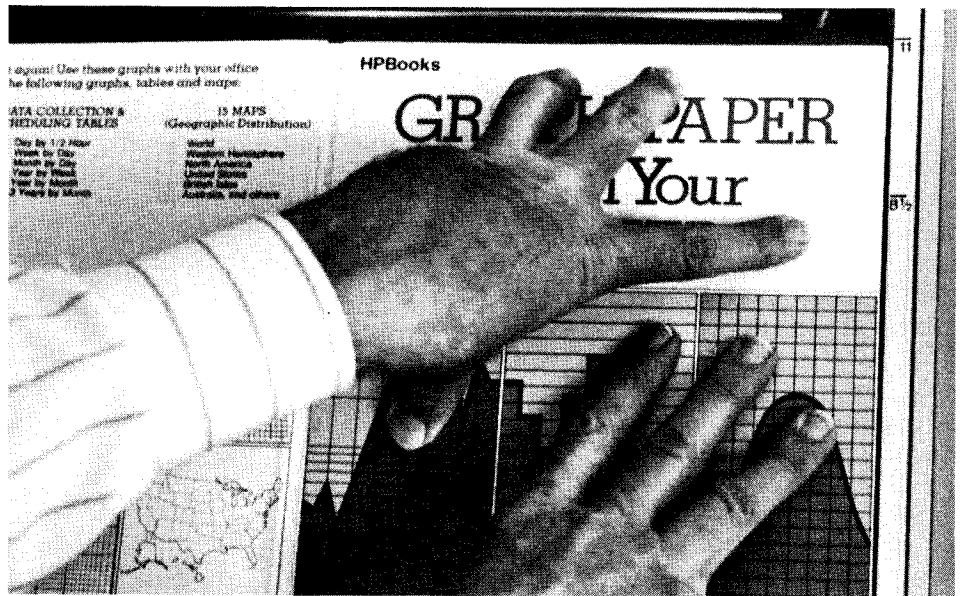
Here's a simple test to determine whether your copier makes same-size copies: Make two pencil marks about 10-inches apart on a sheet of plain paper. Copy this sheet. Fold the resulting copy so the marks are at the fold. Marks on the copy should match those on the original if your copier makes same-size copies.

ENLARGED OR REDUCED-SIZE COPIES

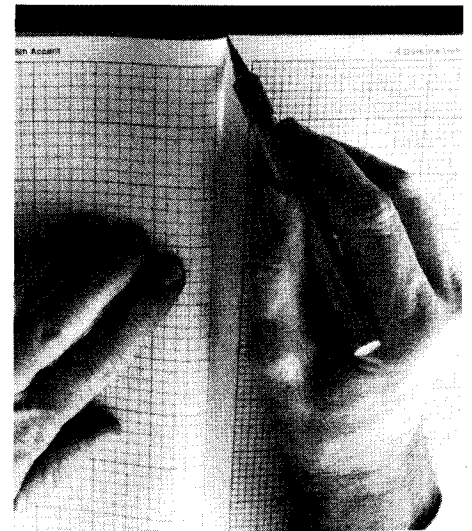
Some copying machines offer fixed or variable reduction. When using this type of machine, it is best to create your graphs full-size before making smaller copies. It is much easier to plot points and draw lines on a full-size copy than to work on one which has been reduced.

LACK OF CONTRAST—LIGHT COPIES

The amount of contrast on a copy will vary with both the "exposure control" and the amount of toner in the copying machine. Make sure there is an adequate supply of toner in the copier if you want black lines.



Be sure to hold the book flat against the copier to get a clean copy with minimal distortion.



When using a sheet-fed copier, remove the page from the book with a razor knife.

This simple test will illustrate whether the copier you use makes same-size copies.

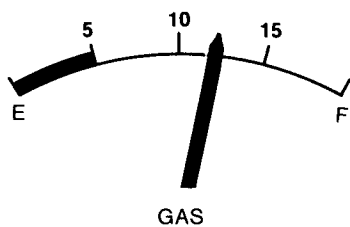


What Is A Graph?

A graph is a pictorial presentation of numbers made by assigning values to each of a set of horizontal and vertical lines called a *grid*. Marks represent positions of a series of numbers. Graphs can be used to show such things as room temperature, daily changes in stock-market prices and the size and shape of a building. This is not as complicated as it sounds. You use graphs every day.

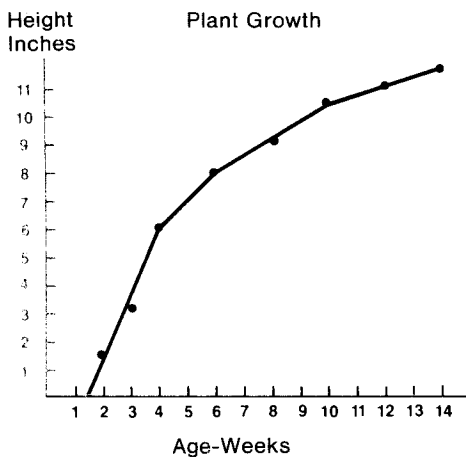
Graphs can be one-, two-, or three-dimensional, meaning they can show one set of numbers, two sets, or three sets.

One-Dimensional Graphs are used to plot a single set of numbers such as the gallons of gas in your car's tank. The thermostat on your home heating system is another example.



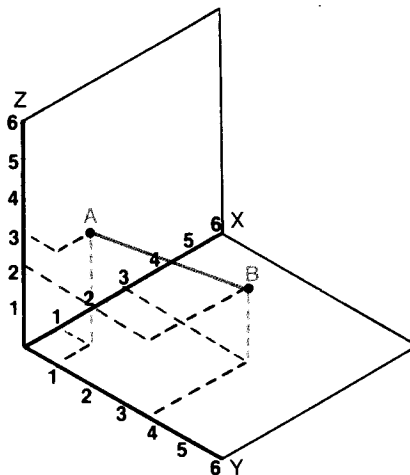
One-Dimensional Graph

Two-Dimensional Graphs are used to plot two sets of numbers. The accompanying graph compares plant growth over a period of time. It could have also related plant growth to amount of light, fertilizer, or water.



Two-Dimensional Graph

Three-Dimensional Graphs are used to plot three sets of numbers. This graph shows a line formed by an equation with three variables X, Y and Z. The line starts at Point A (X=1, Y=1, Z=3) and ends at Point B (X=3, Y=4, Z=2).

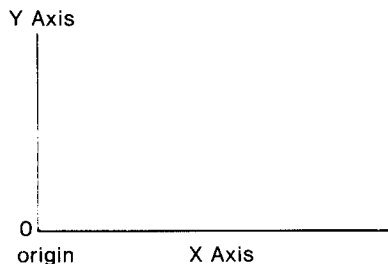


Line between two points (orange)
Point A X = 1 Y = 1 Z = 3 (red)
Point B X = 3 Y = 4 Z = 2 (blue)

Three-Dimensional Graph

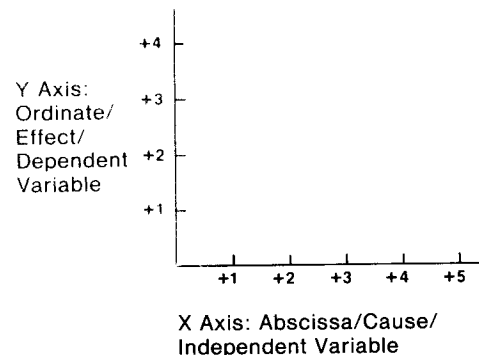
X AND Y AXES

In a two-dimensional graph the *horizontal* line is called the *X axis*. The *vertical* line is called the *Y axis*. The point where they cross is called the *zero point*, *point of origin*, or simply *origin*. Values increase on both axes as they move away from the origin.



X axis or horizontal axis is almost always used to plot *time* or the *cause* of an event. In the plant-growth graph the X axis was used to plot time, but it could have been used to plot water or fertilizer. The cause is often called the *independent variable*. It has a fixed sequence of numbers such as hours in a day, grams of water or fertilizer.

Y axis or vertical axis is almost always used to plot the *effect* of that cause, called the *dependent variable*. It is a set of values varying in relationship to the independent variable; for example, temperature at different times of the day.



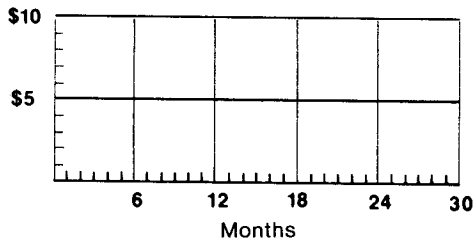
When two variables are dependent on each other, or both depend on some other factor, one variable is arbitrarily placed on the X axis and the other on the Y axis.

The horizontal axis is always numbered with ascending numbers from left to right. A distance along this axis is called the *abscissa*. The vertical axis is always numbered with ascending numbers from bottom to top. A distance along this axis is called the *ordinate*.

DIVISION OR SCALE LINES

If you draw perpendicular lines from the X and Y axes you create a series of squares called a *two-dimensional grid*. These lines are called *divisions* or *scale lines*.

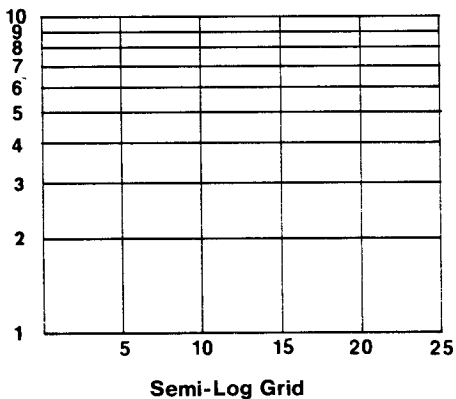
Divisions on an axis must be spaced uniformly in some mathematical progression, but they need not be the same for both. To make graphs easier to read, periodic lines are made bold, or accented.



Different scales on X and Y axes.

For example, the X axis may have 12 divisions per major accent to represent months, with the accent lines marking years. The Y axis may have 10 divisions per major accent to represent dollars, with the major accent lines marking \$10 intervals.

Or, the X axis may have an arithmetic scale while the Y axis has a logarithmic or geometric scale. *Logarithmic* refers to the spacing between grid lines and is usually abbreviated as *log*. The graph below has an arithmetic scale on the X axis and a logarithmic scale on the Y axis. It is called a *semi-log grid*.



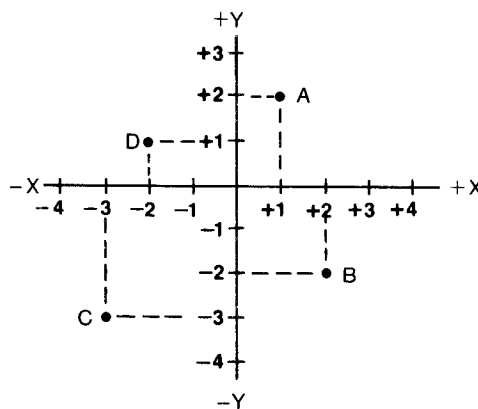
Semi-Log Grid

Scale lines applied to the X, Y and Z axes of a three-dimensional grid look like a series of triangles.

PLOTTING NEGATIVE NUMBERS

Negative numbers (-1, -2, -3, and so forth) can show how far you are below sea level or how much you have overdrawn your bank account. Many phenomena are best illustrated by including negative numbers on a graph.

To show negative numbers, place the origin or zero point in the middle of the paper. Plot negative numbers by extending the X axis to the left, and the Y axis downward. The X or horizontal axis is numbered in ascending negative order from the origin to the left. The Y or vertical axis is numbered in ascending negative order from the origin downward.



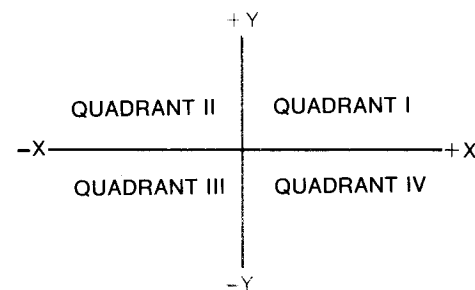
Plotting Negative Numbers

In the above graph

- Point A is in position X = +1, Y = +2
- Point B is in position X = +2, Y = -2
- Point C is in position X = -3, Y = -3
- Point D is in position X = -2, Y = +1

This list of points shows their location or abscissa by horizontal distance from zero on the X axis. The ordinate or distance from zero is shown on the Y axis. Thus the abscissa of Point D is X = -2, while the ordinate is Y = +1.

The four areas created by the two axes are called *quadrants*.



Most graphs deal with *positive* numbers and are plotted in quadrant I. In such graphs the origin or zero point is placed in the lower-left corner. If all four quadrants are used, the origin is placed in the center of the graph.

POOR QUALITY COPIES

Dirty Original—Carefully clean dirt from original with a gum-rubber eraser.

Dirty Glass on Copier—Clean glass with glass cleaner. Recommended glass cleaner will vary with copier. Copiers using liquid toner should not be cleaned with solutions containing ammonia.

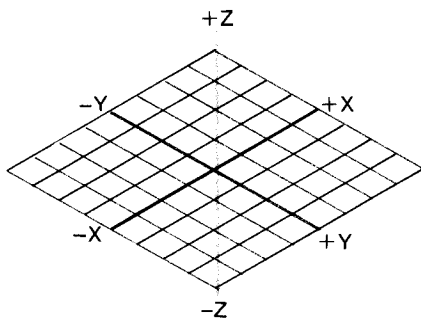
Gray Background from Too Much Toner—Reduce the contrast setting.

Dirty Drum—Clean drum per copier manufacturer's recommendations.

Scratched Drum—Replace drum. Problems may be lessened somewhat by reducing contrast.

THREE-DIMENSIONAL GRAPHS

Three-dimensional graphs are used to plot three sets of numbers. Like two-dimensional graphs, the X and Y axes start from the origin. A third line called the Z axis starts from the origin and extends vertically at a 90° angle thru the plane formed by the X and Y axes.

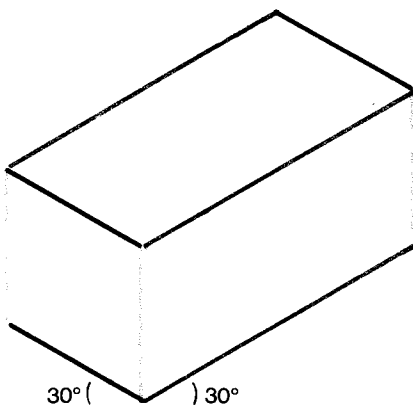


Three-Dimensional Grid

Z Axis is numbered from the origin with positive numbers above the plane and negative numbers below the plane.

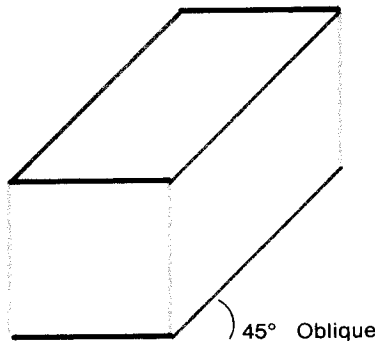
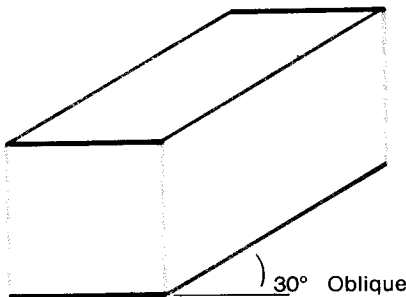
Like the scales of a two-dimensional grid, each scale of a three-dimensional grid must follow a mathematical progression. The scales used on each axis may be different.

Isometric Grids are used to draw an isometric projection in which vertical lines are shown as vertical. Both side and top views are at 30° to the horizontal.



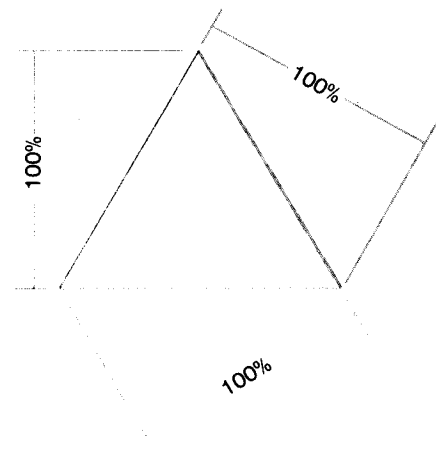
Isometric Projection

Orthographic Grids are used to draw an oblique sketch with front dimensions shown at right angles to each other and the side view at either 30° or 45° to the axis. This is called *orthographic* projection.



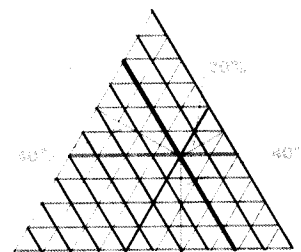
Orthographic Projections

Triangular-Coordinate Grids are used to draw a graph of three percentage relationships, the total of which equals 100%.



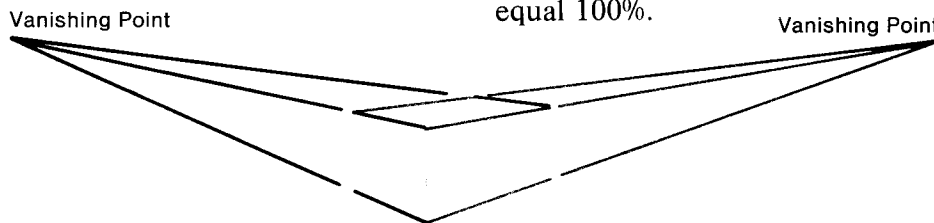
Triangular Coordinate Grid

Each percentage is shown as a line drawn from the center of the base of any side of an equilateral triangle toward its apex. The percentage is represented as the percentage distance from the base toward that apex.



Triangular Coordinate Grid

Perspective Grids are used to draw perspective drawings similar to isometric drawings except that front, side and top views are drawn toward a vanishing point rather than at 30° to the horizontal axis.



Perspective Drawing

When lines representing two percentages are drawn, the third percentage can be found by extending the grid lines that cross the tops of the two percentage lines until they meet. The distance of this point from its base, plus the sum of the distance of the other two points from their bases, will equal 100%.

How To Draw a Graph

STEPS IN DRAWING A GRAPH

Drawing a graph is easy if you use these steps:

- Collect Data
- List Data
- Convert Data
- Round Data
- Determine Graduation of Data
- Select Grid
- Scale Grid
- Label Axes
- Title Graph
- Plot Data Points
- Connect Data Points, if desired
- Identify Data Points, as required

Collect the Data—Use uniform time intervals, or, if the dependent variable (X axis) is not time, use uniform-size data sampling so the points you plot will fall on the X-axis division lines.

List Data—Follow a sequence, starting with the smallest value of X so the values can be plotted from left to right. A series of data-analysis tables is provided on pages 33 to 40, for this purpose. Each has columns for the following operations.

X Days	Y Weight		
1	7 oz.		
2	9 oz.		
3	11-1/2 oz.		
4	14 oz.		
5	18-1/4 oz.		
6	1-5/16 lb.		
7	1 lb. 9 oz.		
8	2 lb. 10 oz.		
9	3 lb. 8 oz.		
10	4 lb. 2 oz.		
11			
12			

Example of Data Collection Days are independent variable, or X axis Weight is dependent variable or, Y axis

Convert Data—Use a uniform system of measurement. You can use metric, English, decimal, fractions or whatever you want as long as the data is in the same units.

X Days	Y Weight	Y Decimal Weight lbs.	
1	7 oz.	0.4375	
2	9 oz.	0.5625	
3	11-1/2 oz.	0.71875	
4	14 oz.	0.875	
5	18-1/4 oz.	1.140625	
6	1-5/16 lb.	1.3125	
7	1 lb. 9 oz.	1.5625	
8	2 lb. 10 oz.	2.625	
9	3 lb. 8 oz.	3.500	
10	4 lb. 2 oz.	4.125	
11			
12			

Data converted to decimal pounds

Round Data—Use the level of accuracy you will need for the graph. For example, round hundredths and thousandths to tenths. Or, round tenths to whole numbers.

X Days	Y Weight	Y Decimal Weight lbs.	Y Weight Rounded 1/10 lbs.
1	7 oz.	0.4375	0.4
2	9 oz.	0.5625	0.6
3	11-1/2 oz.	0.71875	0.7
4	14 oz.	0.875	0.9
5	18-1/4 oz.	1.140625	1.1
6	1-5/16 lb.	1.3125	1.3
7	1 lb. 9 oz.	1.5625	1.6
8	2 lb. 10 oz.	2.625	2.6
9	3 lb. 8 oz.	3.500	3.5
10	4 lb. 2 oz.	4.125	4.1
11			
12			

Decimal data rounded

HOW TO ROUND NUMBERS

There are several ways to round numbers. The most common follows this rule:

- 1.1 rounds to 1
- 1.2 rounds to 1
- 1.3 rounds to 1
- 1.4 rounds to 1
- 1.5 rounds to 2
- 1.6 rounds to 2
- 1.7 rounds to 2
- 1.8 rounds to 2
- 1.9 rounds to 2

With this rule a number will round *down* four times of the nine and will round *up* five times of the nine, introducing a *statistical bias*.

A preferred rule reduces statistical bias by rounding 0.5 to the next-lower number half of the time and to the next-higher number the rest of the time.

Under this rule, rounding increases an *odd* preceding number when 0.5 is rounded but does *not* increase an *even* preceding number when 0.5 is rounded, thus:

- 1.5 rounds to 2
- 2.5 rounds to 2
- 3.5 rounds to 4
- 4.5 rounds to 4

Because the preceding number has an equal chance of being odd or even, no statistical bias is introduced. 0.1 through 0.4 still round down to the next lower number and 0.6 through 0.9 are rounded to the next-higher number.

Determine Graduation of Data— Examine the data in your table. Select a graph paper that can cover the range of the data on *both* axes, with major divisions corresponding to the nature of the data.

If the data is in fractions, use paper with the same number of divisions per accent as the denominator of the fractions. For example, fractions expressed as fourths would use paper with 4 divisions per accent. If the data is in days of the week, use 5 divisions per accent to show 5 working days, 6 divisions per accent to show 6 working days, or 7 divisions per accent to show 7 days.

When data covers a range of more than one decimal order of magnitude (for example more than 1 to 10 or more than 10 to 100) you may wish to use a *semi-log* or *log* grid. They show the *percentage change* rather than the

arithmetic change of the data. More about these grids is in the logarithmic section, page 19.

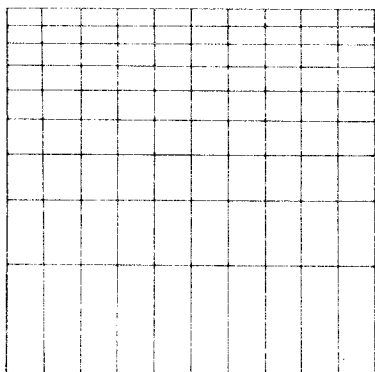
Select Grid— Select a graph paper with enough graduations so you can accurately plot the data. Don't use more lines than the data requires because it makes the graph hard to read.

Scale the Grid— Scaling changes can cause many visual distortions as shown in the accompanying illustrations.

There is no firm rule as to what is correct scaling, but the general practice is to locate the lowest point on the Y axis within the bottom 20% of the graph, and the highest point within the top 20% of the graph. Try to have the plotted line at a 30° to 40° angle to the X axis.

Graph proportions are usually square or rectangular with the ratio between the sides not exceeding 7 to 10.

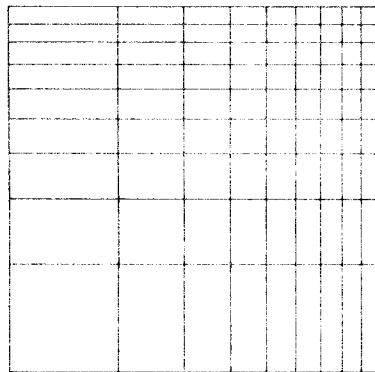
Log Scale



Arithmetic Scale

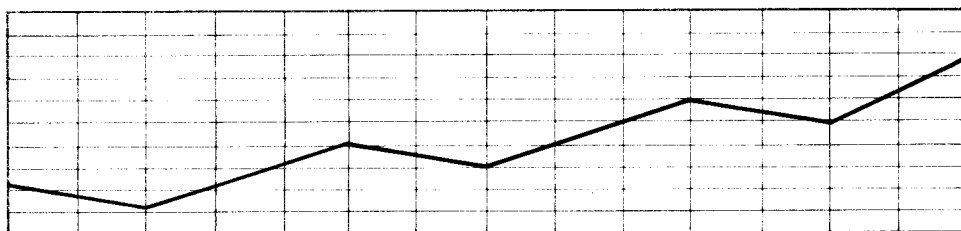
Semi-Log Grid

Log Scale

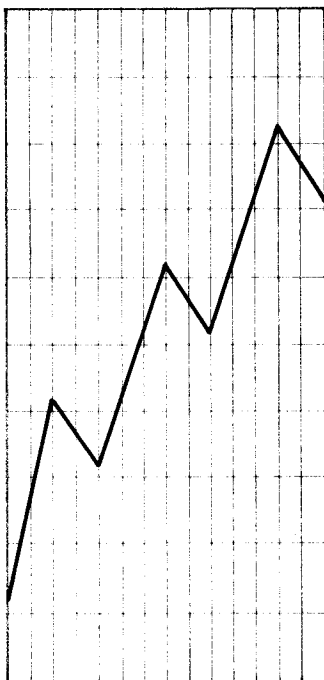


Log Scale

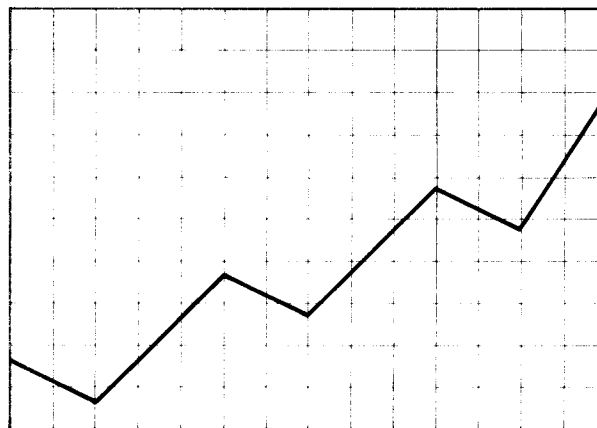
Log-Log Grid



Vertical Compression



Horizontal Compression



Normal Grid

Break in Axis—Sometimes it is necessary to show small changes in data of large magnitude. This can be done by interrupting the axis with a break and showing only the top portion of the data.

Breaks distort the amount of change because they do not show a true picture of the relation of the data to the base. When you use a break, extend it all the way across the graph so it is easy to see.

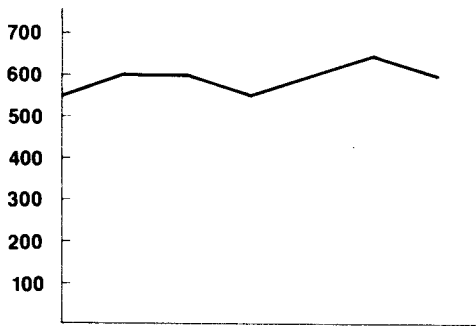
Label Axes—Each axis should be clearly labeled with its numeric values and with its description, for example:

Population in Thousands
Price in \$1,000
Percent
Fiscal Years

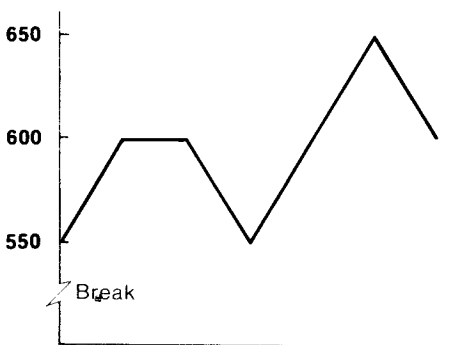
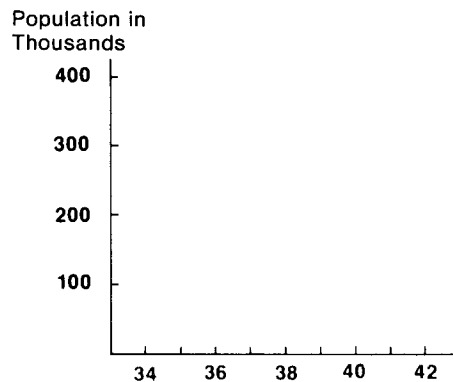
Horizontal labels are easier to read when used on both axes because you don't have to rotate the page to read them.

Multiple Scales on X & Y Axes—

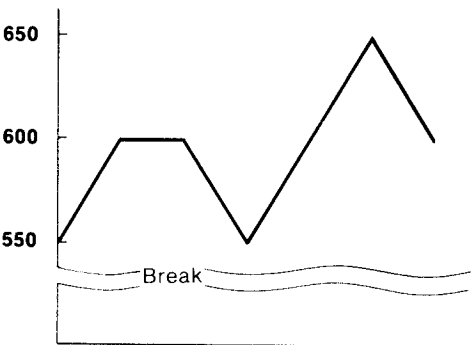
When multiple sets of data with different ranges are plotted on the same graph it may be necessary to use more than one scale on either the X or Y axis. Scales may be placed on the same side of the graph or on opposite sides.



Data with no break

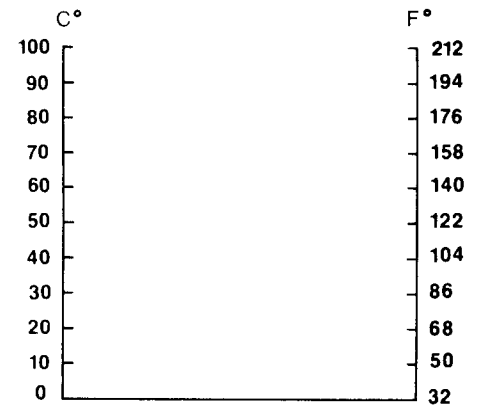
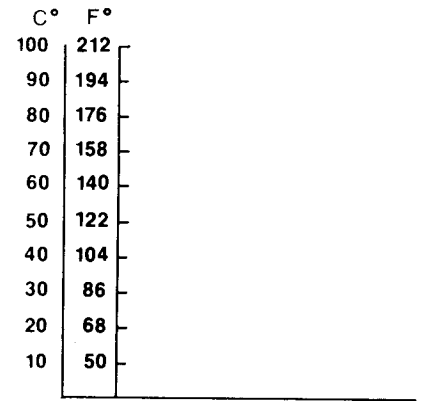


Enlarged scale with break



Preferred break extends across graph

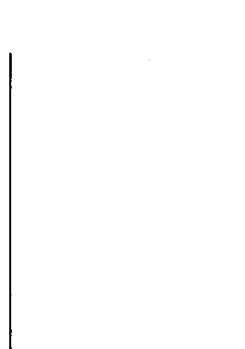
Use of break in data to emphasize change



Dual scales used on Y axis for the same data

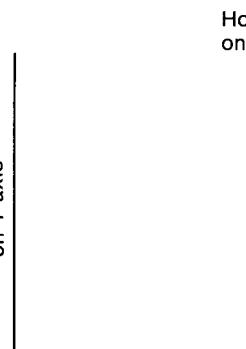
However, vertical labels are perfectly acceptable. Although awkward for long titles, top-to-bottom labels can also be read without rotating the page.

TOP
TO
BOTTOM
ONLY
AXIS



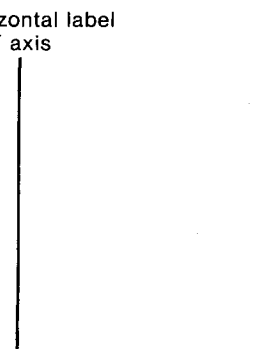
Horizontal label on X axis

Vertical label on Y axis



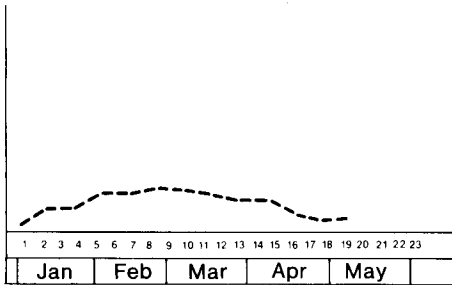
Horizontal label on X axis

Horizontal label on Y axis



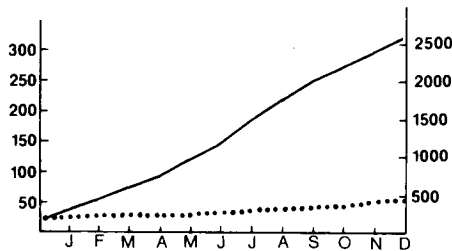
Horizontal label on X axis

You may also use more than one scale on the X axis to show days, weeks and months.



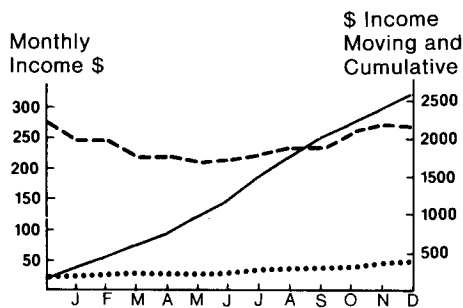
Weekly and monthly scale on X axis

Use more than one scale on the same graph where the two scales represent different but related data. This is useful for showing related information such as dollar sales and unit sales or purchasing power of the dollar in percent and gross national product in dollars.



Dual scales used for different data

Z Graphs—Where the graph shows a *current status*, a *cumulative status* and a *moving average* it is called a *Z graph*. These are used to show economic and business trends and data comparison on a year-to-date basis.



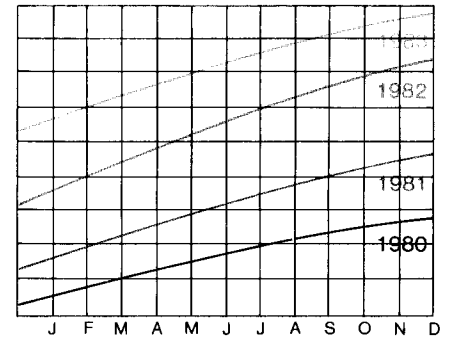
Z Graph

When you want to make a master graph, type the graph title on an adhesive label.

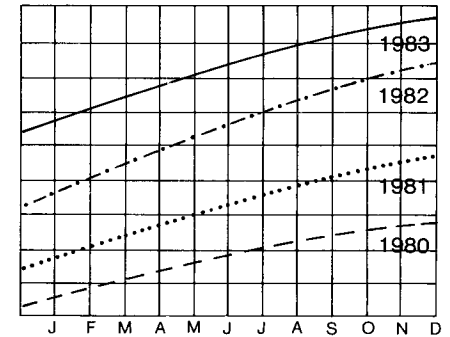
Multiple-Curve Graphs—When you want to compare the data from several years, you may superimpose the curves on the same graph. When you do this, January of the first year will be on the same division line as January of the second year and so on. Each curve must be identified. This type of graph is called a *multiple-curve graph*.

Multiple-curve graphs with curves approaching or crossing each other should have each curve labeled for clarity. Colors may be used, but when copied, all colors will reproduce as black on most copiers. A better choice is to use different types of lines for each curve: One can be a solid line, one can be broken into dashes or dots, another can be a combination of dashes and dots. Colors can be applied to each of the curves on each copy of the graph if you want to make each curve highly visible for emphasis.

Title the Graph—Where possible, titles should read parallel to the X axis so they are easily read without turning the page. Each graph should have a full title. It is usually placed at the top of the graph, at

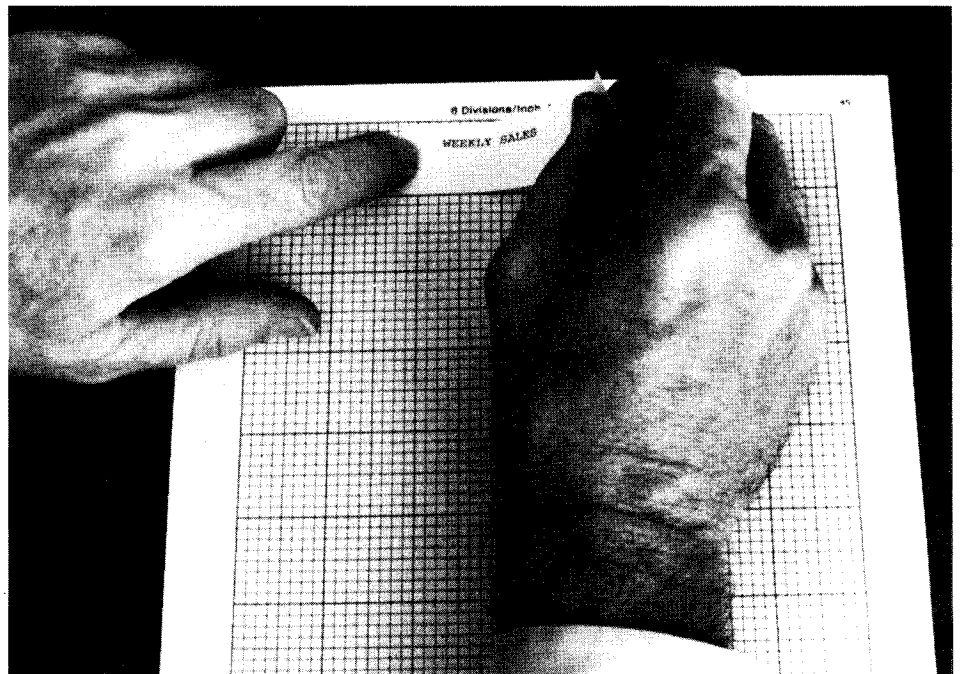


Color-identified lines

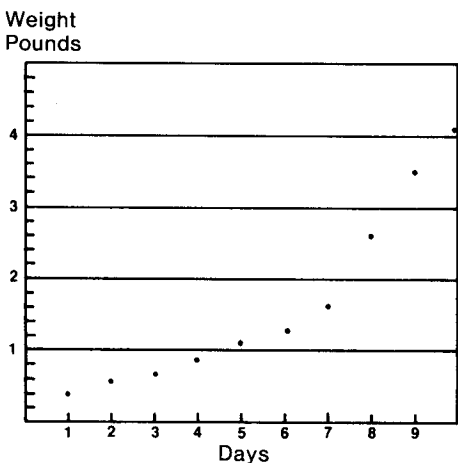


Different types of lines

the bottom of the graph or in a block inset within the graph. If you are working directly on graph paper, a block inset is easily accomplished by applying an adhesive label over the section where you wish the title. You may want to type or letter the label before applying it to the graph.



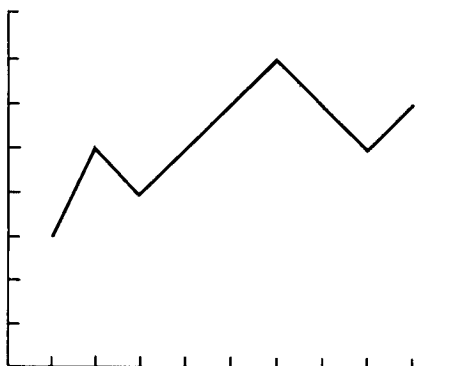
Plot Data Points—Using data from the table on page 7, use a pencil to plot the first data point at its X and Y coordinates.



WEIGHT GAIN OVER TIME

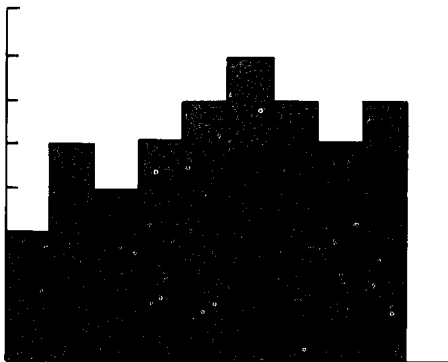
Plot all data points on the graph. Examine the graph to see if there are unusual variations in the points plotted. If there are any, double-check them against the data to make sure there are no plotting errors. Corrections are easy to make while all of the points are still in pencil.

When the X axis represents time, plot data on the line which represents the *end* of the time period.



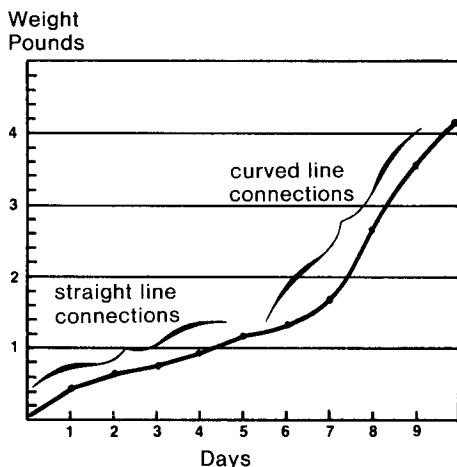
Line graph shows data at end of period

If you are making a bar graph, the space between lines indicates the time period *ending* with the line indicated on the X axis.



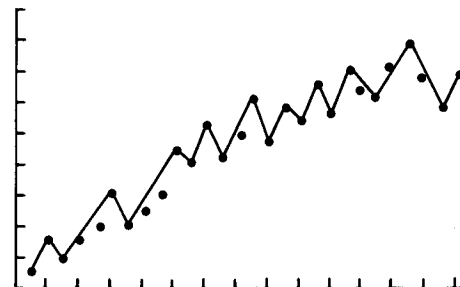
Bar graph shows data in the period before end of line

Connect Data Points—Draw a line to connect each point you have plotted. You can use a ruler to form a series of straight lines or a French curve to draw a curved line. Lines connecting data points on a graph are usually called *curves* even if they are straight lines.

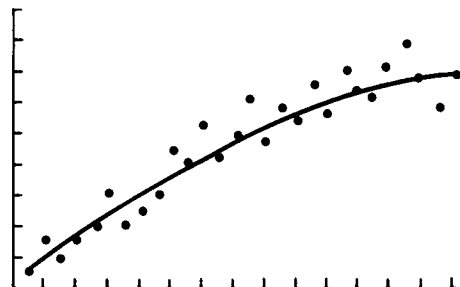


Data points may be connected with straight lines or a French curve

The line may be smoothed by connecting extreme peaks; by drawing the line to approximate the location of the data points rather than exactly to them; or by using a *moving average* as described on page 13.



Connecting extreme peaks



Smoothing by approximation

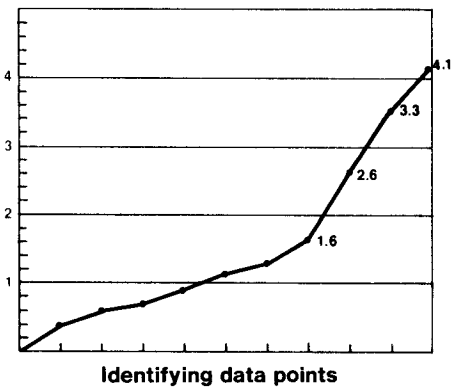
If more than one line is to be drawn on the graph, first plot all the points for one line and then draw it—and so on for each additional line.

When you draw more than one line or curve on the same graph, use the following types of lines:

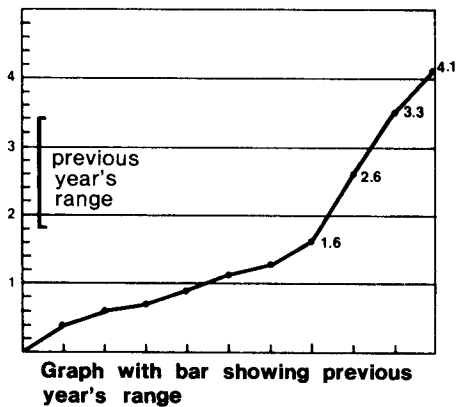
- Primary data
 - - - - - Secondary data
 - Tertiary data
- Where more than three sets of data are presented, use lighter versions of these lines.
- Primary data
 - - - - - Secondary data
 - Tertiary data
- or combinations
- Primary data
 - - - - - Secondary data
 - Tertiary data

Do not use heavy dots on lines unless they represent data points.

Identifying Data Points—It is often desirable to identify each plotted point with a small dot for later reference. Further identification may be added by writing the value of the point next to it where it will not interfere with the plotted line. If you want to show the range of the data that occurred in the period before the graph began, use a vertical bar along the left side of the graph.



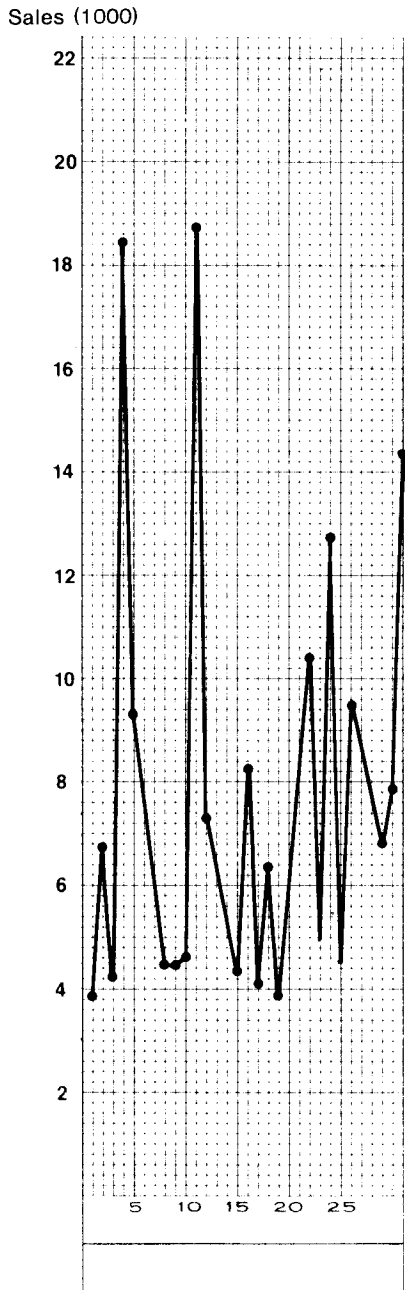
Identifying data points



Graph with bar showing previous year's range

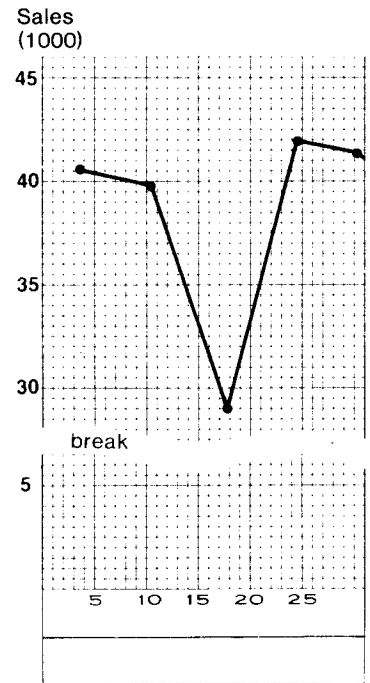
PLOTTING DATA WITH EXTREME VARIATIONS

Plotting a series of data points often produces a graph with such extreme variations that the meaning of the data is obscured.



Graph showing extreme variation

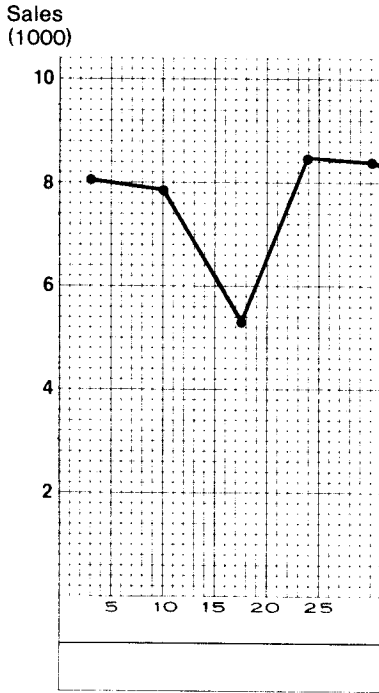
Generally, extreme variation can be reduced by using a broader data base. For example, if day-to-day variation is too extreme, plotting weekly totals of the same data will usually produce less variation and plotting monthly totals further reduces the variation.



Weekly Sales—Units

Graph is smoothed by plotting a longer time interval

When it is important to show quantitative amounts, plot the *daily arithmetic average* of the data for that week or that month. The daily arithmetic average is easily calculated by adding the data for the week and dividing the total by the number of days data was generated that week.



Weekly Average Daily Sales—Units

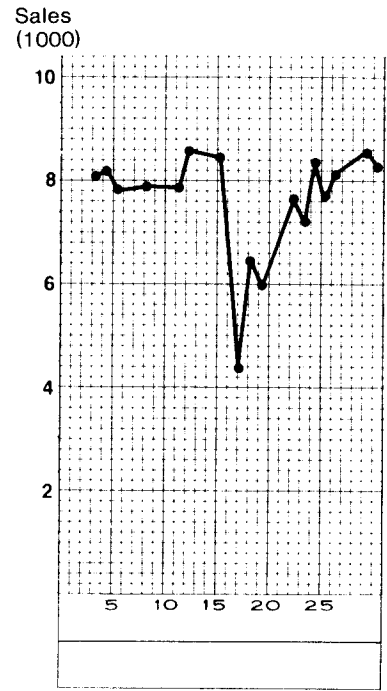
Quantitative Relationship Shown by Average Daily Sales

MOVING AVERAGE

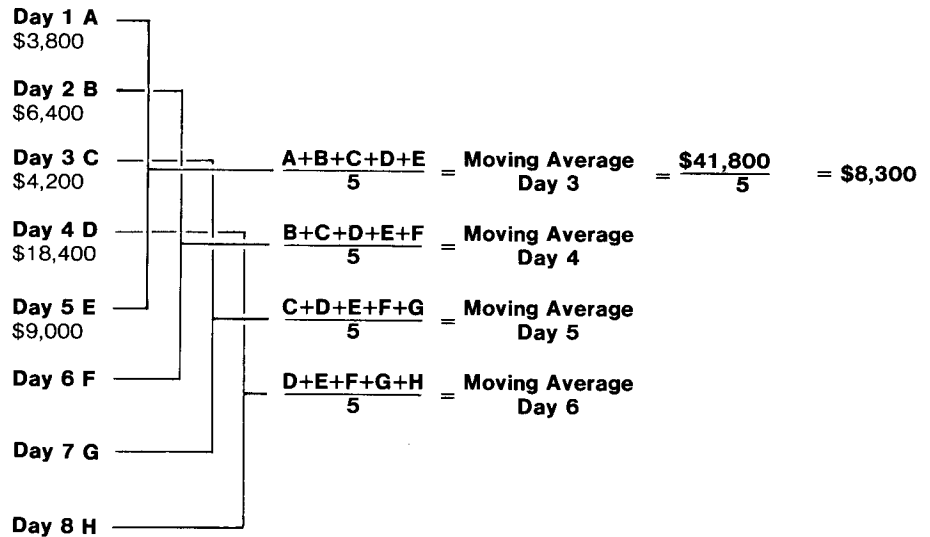
The preceding techniques reduce data variation by plotting a group of data, and so reduce the number of points shown. When it is desirable to reduce data variation and still plot one point for each data sample, you use a moving average.

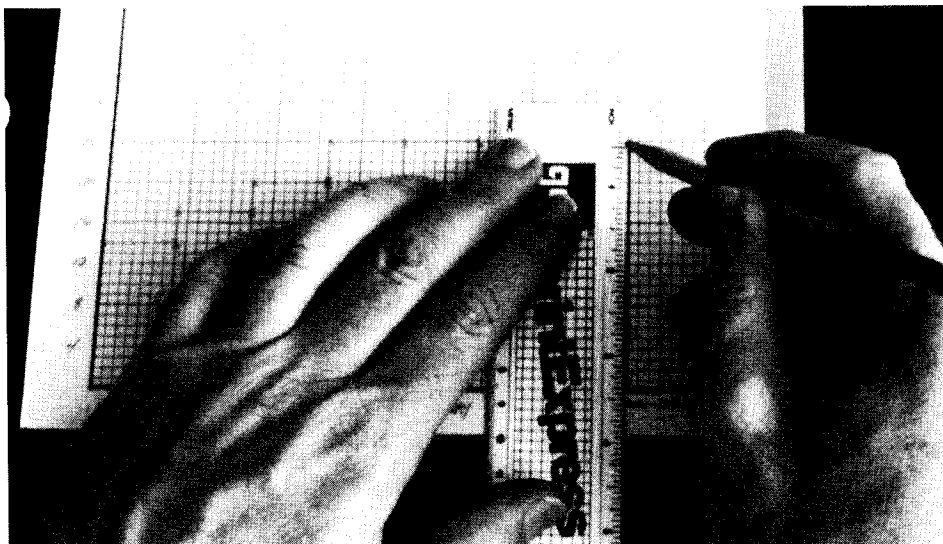
Here is an example of a 5-day moving average: The first 5 days' sales of 3,800, 6,400, 4,200, 18,400, and 9,000, are totaled. The sum of 41,800 is divided by 5. This 8,300 average is plotted at day 3, the center point of the 5 days. The same is done for days 2 through 6, and the result is plotted at day 4.

You can use any time period for the average: 5 days, 10 days, a month or a year. It takes a little experimentation to find out what time period works best for a particular problem.



Daily Sales—Units
5-Day Moving Average





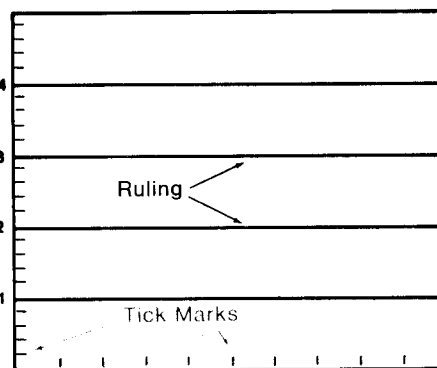
By tracing the graph onto tracing paper you can remove unnecessary lines and make the graph cleaner and easier to understand.

TRACING A GRAPH

You may want to make a graph with no grid lines. First draw the graph on a copied graph, then trace it on plain paper. Copy only the parts you want to show. You may want to include X and Y axes.

When tracing, allow adequate space to the left and bottom for vertical and horizontal scales.

Because the grid will not show on your traced copy, you will have to provide calibration and labeling. This may be done in three ways: ruling the most significant horizontal and vertical lines, using *tick marks* on the most significant horizontal and vertical lines, or using *rulings* for the major-significant horizontal and vertical lines and using *tick marks* for the less-significant horizontal and vertical lines.



Use of tick marks and ruling

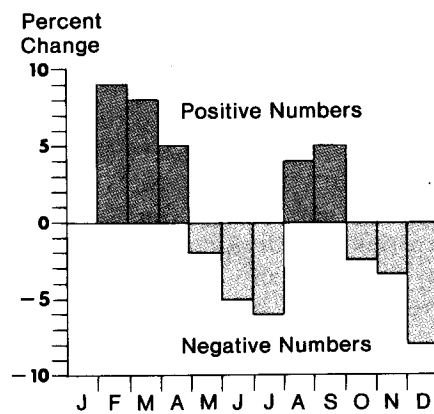
You may want to eliminate horizontal and vertical lines in the area where there is no data. This uncluttered area can be used for titles and explanations.

BAR GRAPHS

Bar graphs show one or more bars, the parts or length of which show data size. They are similar to line graphs except that individual bars are drawn vertically from the X axis to the data point, rather than connecting the data points with a line.

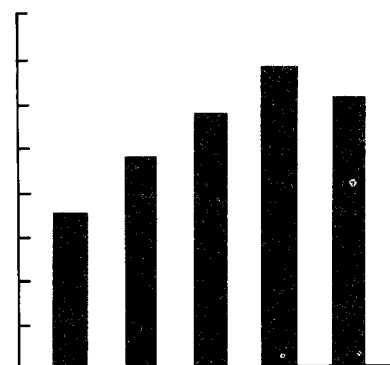
Bar graphs may also be drawn with horizontal bars originating from the Y axis.

Negative numbers may be shown on bar graphs by showing the bar below the X axis or to the left of the Y axis.

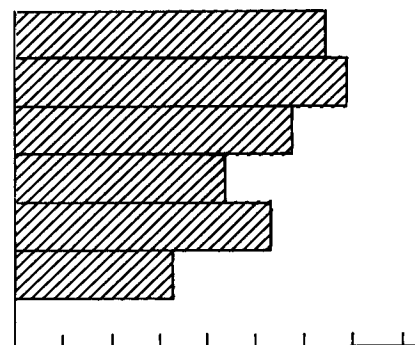


Changes in Sales — Percent

Negative Numbers on a bar graph



Multiple Bar Graph



Bar graphs can be drawn horizontally

PLOTTING DATA

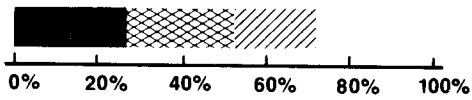
Data points should be plotted on X-axis lines representing the end of the time period, except on bar charts. Bar charts should show each bar in the space before the division line showing the end of the data period. Data should be plotted in pencil first, then drawn in ink.

Division lines are not needed between bars. Tick marks or a minimum of division lines are needed on the other axis to show the bar lengths.

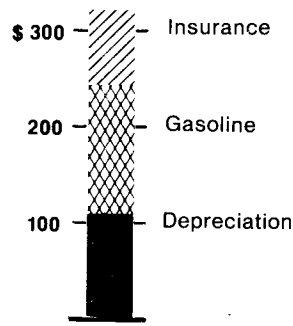
When bars originate from the X axis and show time, bar width shows the period covered by the data. The right side of the bar indicates the end of the period.

Bar graphs may be used to show data or percentages. They should always originate from zero unless they are drawn on a log scale.

SINGLE BAR GRAPHS



Horizontal Bar



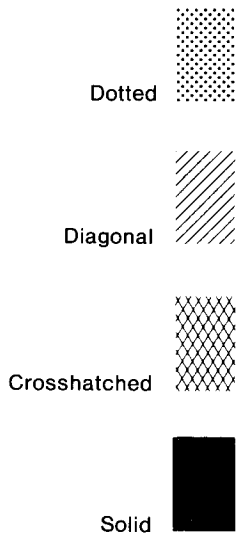
Vertical Bar

DATA SOURCE

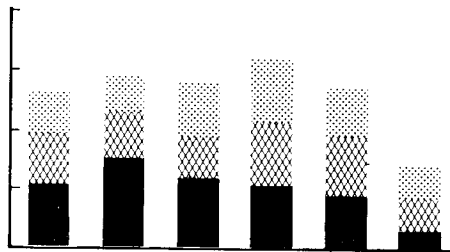
All graphs should note data source, time, location, and other pertinent information.

Identifying Data

Bars may be solid or shaded for identification of data. The illustration shows preferred shading patterns for bar graphs.



Component or segmented-bar graphs show component parts and make comparisons in the manner of the surface graph. Single-component bar graphs are used like pie graphs. They should show the largest data on the bottom with the heaviest shading. As you move upward showing data in decreasing order of size, use progressively lighter shading.



Component or Segmented Bar Graph

Shaded tapes and rub-on transfer materials are sold at art, blueprint and office-supply stores for this purpose.

Identification of shadings may be given in a separate box rather than on the graph itself.

Multiple-bar graphs are used to make comparisons of data points.

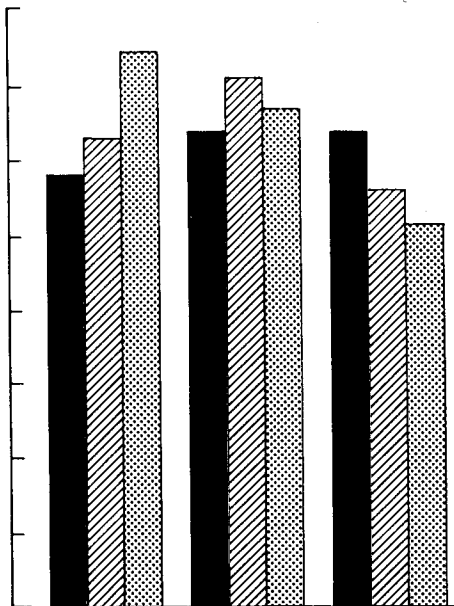


Self-adhesive patterned tape, which is available in a variety of sizes and designs from art-supply stores, will improve the graphic message of any bar graph.



A good burnishing tool for rub-on transfers is the cap of a ball-point pen.

Compound-bar graphs show side-by-side comparisons of data within the same group, and show side-by-side comparison of groups.



Compound Bar Graph

SCALES

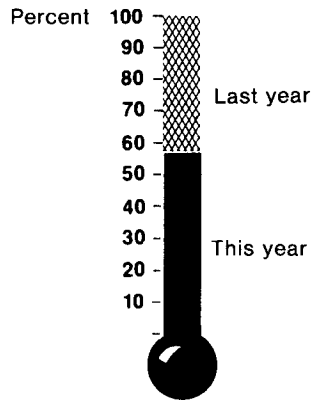
A vertical scale should be fine enough so it is easy to make and read the chart. The horizontal scale should be appropriate for the data used, for example, days or weeks.

THERMOMETER GRAPH

The thermometer graph is often used to represent achievement of goals. It allows plotting percentage elements less than or greater than 100%. It also provides a convenient way to present quantitative and percentage information in highly effective visual form.

The same shading and identification rules for bar graphs are used for thermometer graphs. In fact, a thermometer graph is a single bar graph with a bulb on the bottom. You can plot quantities greater than 100% by extending the graph above the 100% mark.

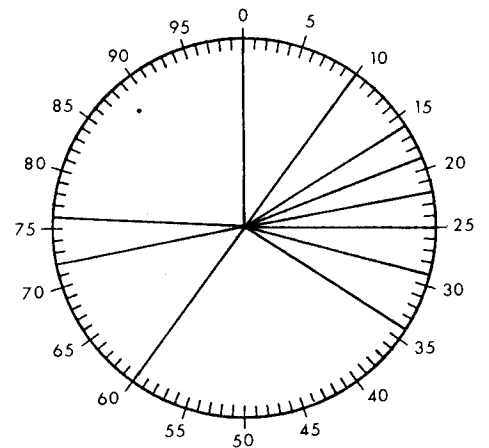
Thermometer graphs can also be shown horizontally.



Thermometer Graph

PIE GRAPHS

A *pie graph* (named after the dessert, not the Greek letter) is a circle divided into segments representing its components. It is another way to illustrate percentage distribution. A pie graph is a circle with the circumference representing 100%. It is divided into wedges representing percentages of a whole. Several pie graphs are on pages 79 through 81. Pick the size that will be easiest to scale.

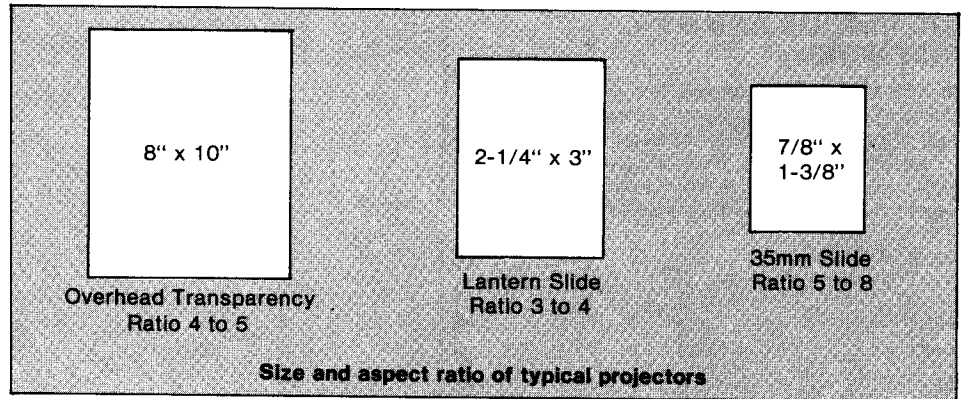
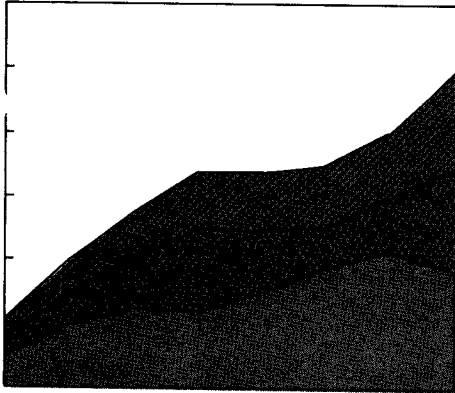


Pie Graph or Circular-Percentage Graph

The best way to make a pie graph is to prepare a table listing the items to be shown on the graph. Use this table to calculate the percentage of the total each item represents. Mark these percentages around the circumference and draw lines from the centerpoint to the circumference to form wedges showing percentages.

Percentage marks around the graph may be covered with opaque white correction fluid or left in place. You may label each wedge with the percentage or amount it represents—or both—with its title. Make your graph copies easier to read by coloring or shading each wedge.

There are two major limitations of the pie graph. It can only represent a static moment in time and it cannot exceed 100%.



If the graph is to be projected, size it to fit the projector.

SURFACE GRAPHS

Surface graphs show data size by the relative amount of surface between two lines. They are similar to line graphs except they have more than one line. The top line represents the cumulative total. Each of the lines below it represents a part of the total amount. The same shading patterns used for bar graphs are used for surface graphs.

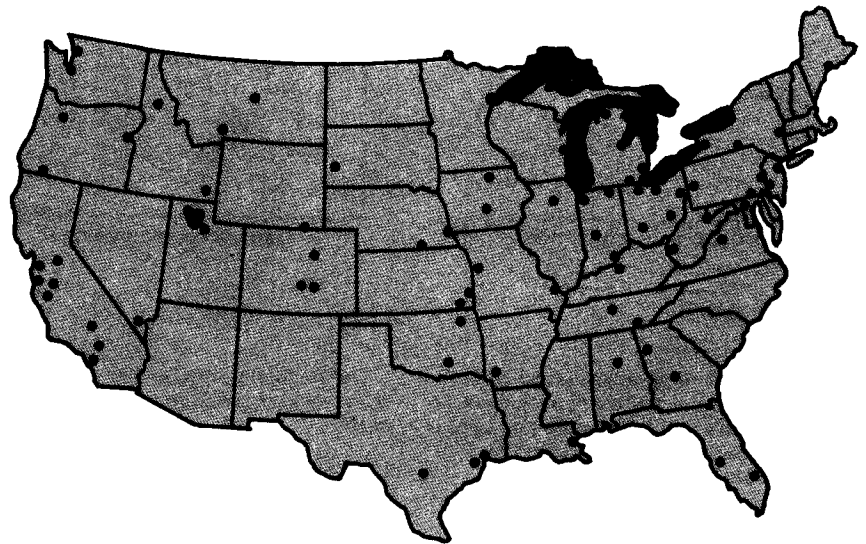
REPORTS

If the graph is a part of a report, try to position the graph so it is not necessary to rotate the page to read it. If it is necessary to rotate the page, the graph should read correctly when you rotate the page a quarter turn clockwise.

GEOGRAPHIC DISTRIBUTION GRAPHS

The geographic distribution graph is an outline map used to show data locations plotted on the map. Typical geographic distribution graphs include weather or population distribution.

Geographic graphs can be combined with pie or bar graphs to show distribution of relative quantities. Applications include plotting geographic information such as airline routes or sales territories.



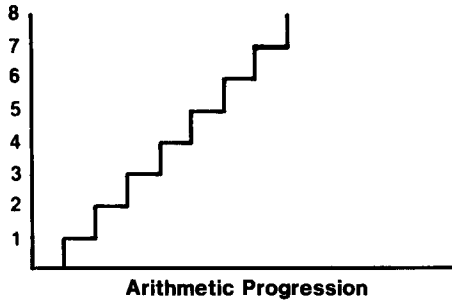
Geographic Distribution Graph

LOGARITHMS AND HOW THEY WORK

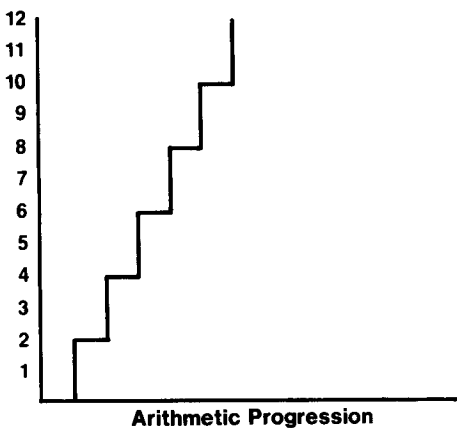
An arithmetic graph shows the *amount of change*. A logarithmic graph shows the *percent of change or ratio of change*.

Like stairway steps, the change between each number in an *arithmetic progression* is always the same. It can be 1 as in

1 2 3 4 5 6 ...

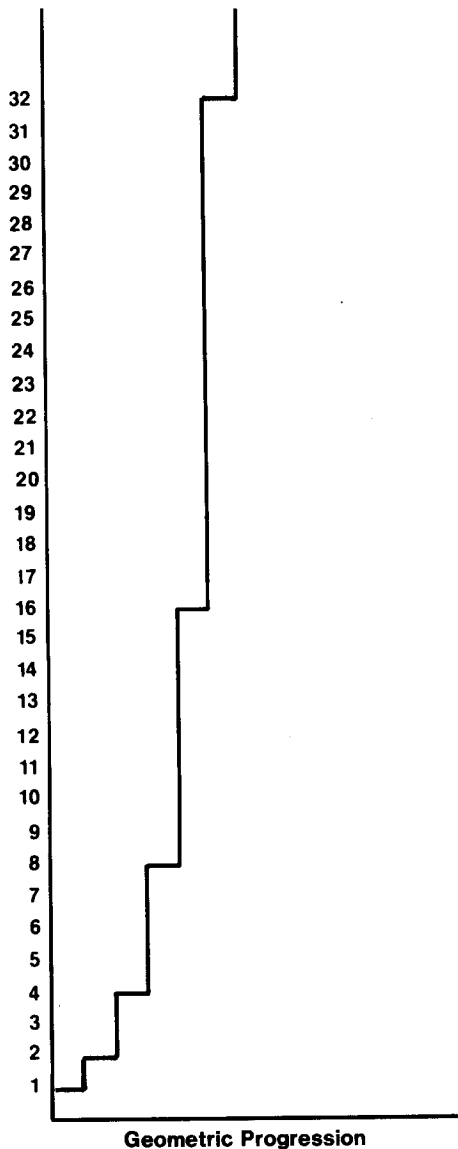


It can be a difference of 2 as in
2 4 6 8 10 12 ...



In a *geometric progression*, the size of each step varies but the *percent of change* is constant. Thus in the following geometric progression, each step is multiplied by 2 to find the value of the next step.

2 4 8 16 32 64 ...



The multiplier can be 5 or 10 or 50 or any other number, *but the change is always the same*.

Here's a geometric progression with 10 as the multiplier:

10 100 1,000 10,000
100,000 1,000,000 ...

The progression 2, 4, 8, 16, 32, 64 can also be written as

$2^1 2^2 2^3 2^4 2^5 2^6 \dots$

and the progression 10, 100, 1,000, 10,000, 100,000, 1,000,000 ... can be written as

$10^1 10^2 10^3 10^4 10^5 10^6 \dots$

The small number at the top right is called an *exponent*. The large number is called the *base*, thus when 1,000 is written as

10^3

10 is the base and ³ is the exponent. The exponent is the number of times the base number is multiplied by itself to produce the number. Thus 10^3 is the same as $10 \times 10 \times 10$, which is 1,000.

Before the development of slide rules and digital calculators, mathematicians took advantage of the fact that numbers can be multiplied by each other by expressing them as a base with an exponent and then adding the exponents. The exponent is called a *logarithm*.

The *common logarithm* (log) of a number is the *exponent* to the base ten of that number—that is, the number of times ten is multiplied by itself to make that number. Thus the common logarithm 2 means 10×10 or 10^2 and equals 100. The following table shows a list of the simple powers or exponents of 10 and their logarithms:

Number	Power	Logarithm
0.001	10^{-3}	-3
0.01	10^{-2}	-2
0.1	10^{-1}	-1
1	10^0	0
10	10^1	1
100	10^2	2
1,000	10^3	3
10,000	10^4	4
100,000	10^5	5

Adding the exponents of numbers causes the base numbers (the 10 in this case) to be multiplied. Thus $10^2 \times 10^3 = 10^5$, or expressing it another way— $100 \times 1,000 = 100,000$.

Now let's do the same thing in logarithms. The table shows the log of 100 is 2 and the log of 1,000 is 3. When you add the logs 2 and 3, the total log is 5. In the table, log 5 is the same as the number 100,000 which is the same as the product of $100 \times 1,000$.

Division may be accomplished by subtracting the logarithm of one number from that of another and looking up the number represented by the resulting logarithm. For example $\text{Log } 4 \text{ minus } \text{Log } 2 = \text{Log } 2 = 10,000 \quad 100 = 100$.

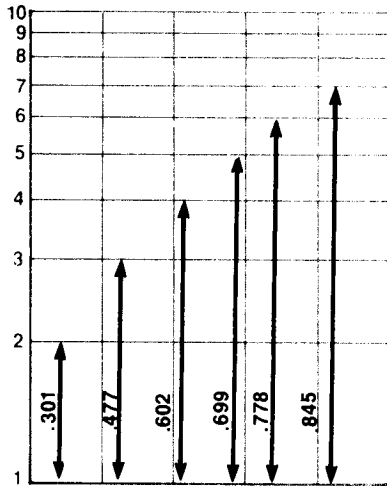
Numbers between 1 and 10 have logarithms between 0 and 1. They are expressed as decimals. Tables of logarithms expressed as decimals, sometimes to ten or more places, are in many technical books. You can buy books devoted solely to tables of logarithms. This table shows the common logarithms or exponents to the base 10 of the numbers from 1 to 10 rounded to 4 places:

Number	Logarithm
1	0.0000
2	0.3010
3	0.4771
4	0.6021
5	0.6990
6	0.7782
7	0.8451
8	0.9031
9	0.9542
10	1.0000

To use this table, look up the logarithms of two numbers. Add the logarithms together to find the logarithm of their product. Look up the logarithm to find their product. Thus the logarithm, or *log*, of 2 is 0.3010 and the log of 3 is 0.4771. Adding the log of 2 and the log of 3 ($0.3010 + 0.4771$) gives 0.7782. When you find this number in the preceding table, you will see that 0.7782 is the log of 6, which is the product of 2×3 . Thus, adding the logs of two numbers is the same as multiplying those two numbers.

LOG GRAPHS

A logarithmic graph shows *percentage change*, not *arithmetic change*. A certain distance on the scale at any location represents the same percentage change as that distance at any other location on the scale. Because log-graph paper shows percentage change, it is sometimes called *ratio paper*.

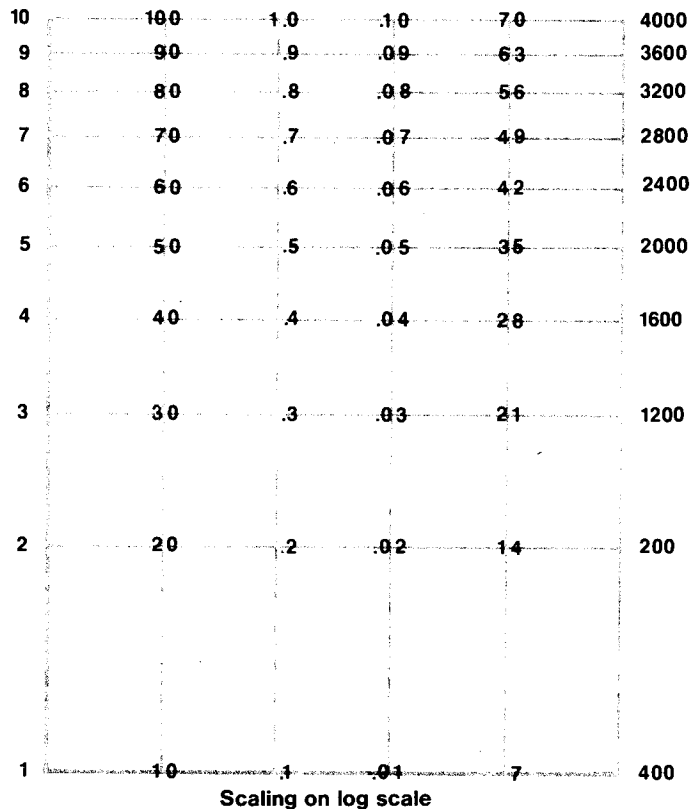


Position of numbers on log scale

To make a logarithmic graph, a log scale is laid out so the distance between 1 and 2 is equal to 0.3010 of the distance from 1 to 10; the distance from 1 to 3 is 0.4771 of the distance between 1 and 10. The log of 3 is 0.4771, the scale position of 3 is placed 4771/10,000 of the distance between 1 and 10, and so on. Each step gets smaller and smaller.

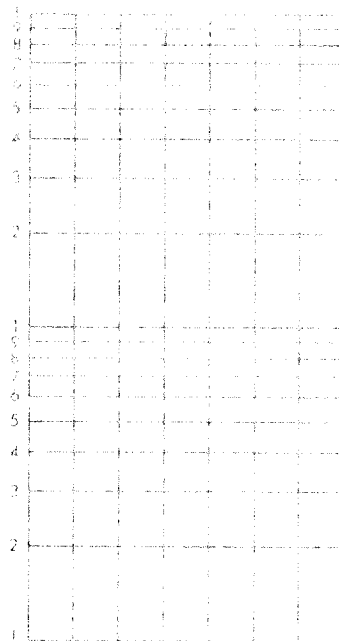
A log scale has no zero because the scale progresses upward by multiplication and downward by division, rather than by addition and subtraction. Each log scale is called a *cycle*. Where two cycles are put end to end, the scale is called a *two-cycle scale*. When three cycles are used, it is called a *three-cycle scale*, and so on.

Each cycle represents a change from log 0 to log +1 or 10^0 to 10^1 . Because it shows a change of 10 times the starting number, it can show the change from 1 to 10, or 10 to 100, or 100 to 1,000. It can also show the change from 0.1 to 1 or 0.01 to 0.1. Any convenient number can be assigned to the base line.

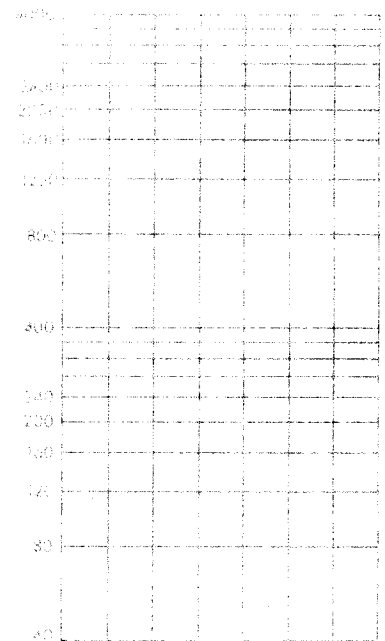


A two-cycle scale represents the change from 10^0 to 10^2 or 1 to 100—a change of 100. A three-cycle scale represents a change from 10^0 to 10^3 or 1 to 1,000—a change of 1,000.

You can multiply the numbers on a log scale by any number or decimal you wish. For example, the scale can be 1 to 10, 4 to 40 or 60 to 600.



2-Cycle Log Scale

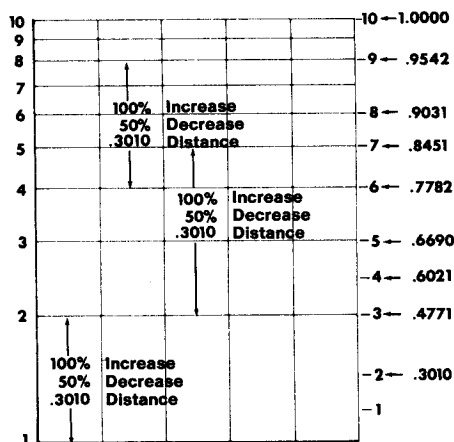


How to scale a two-cycle log grid

Numbering—Semi-log graphs are numbered on the right as a guide and to allow room for labeling on the left. Log-log graphs are numbered on the top and on the right as a guide and to allow room for labeling on the bottom and to the left.

PLOTTING PERCENTAGES ON LOG GRAPHS

The distance from 10 to 20 is 0.3010 of the distance from 10 to 100. The distance from 40 to 80 is also 0.3010 of the distance from 10 to 100. The increase from 10 to 20 and 20 to 40 are both increases of 100%. Any change of 100% will occur over the same distance anywhere on the graph.



Percentage change on log scale

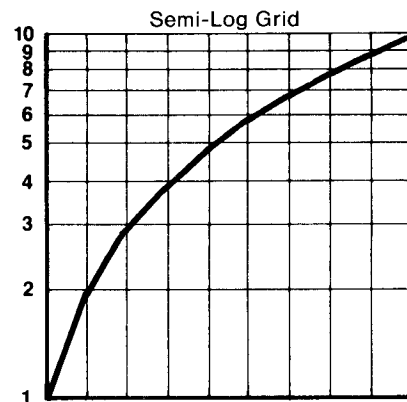
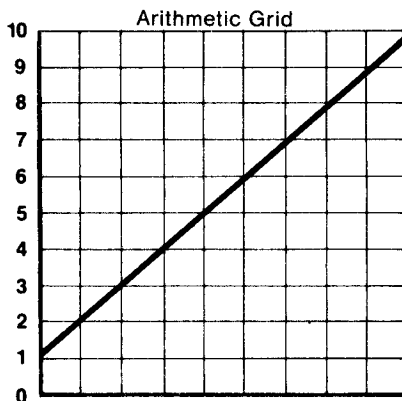
In the same manner, any percentage change—say 30%—will occupy the same distance as any other 30% change.

Logarithmic graph paper, called *log paper* for short, or sometimes *ratio paper*, is available for both types of graphs and I have included both kinds in this book.

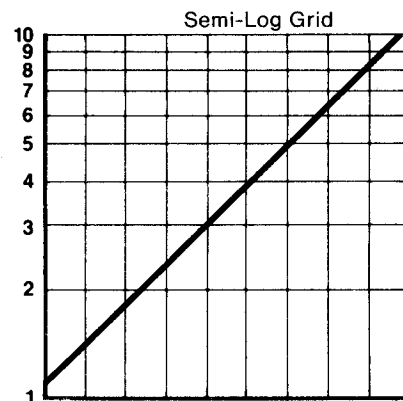
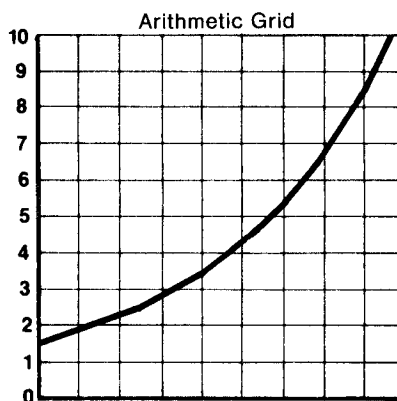
Graphs which cover a range of one decimal order of magnitude (10 to 100, 10^1 to 10^2 or Log 1 to Log 2) are called *single-cycle*. Graphs covering a change of two decimal orders of magnitude from 1 to 1,000—Log 1 to Log 3, are called *two-cycle*, and so on.

This book provides semi-log graphs with 1 to 10 cycles. It also provides log-log graphs with 1 to 10 cycles on the X axis, each with 1 to 10 cycles on the Y axis.

When you plot a geometric progression on a log scale it



Arithmetic progression on arithmetic and semi-log grids



Geometric progression on arithmetic and semi-log grids

becomes a straight line, but when you plot an arithmetic progression on a log scale it becomes a curved line.

Arithmetic graphs measure *arithmetic* change. Log graphs measure *percentage* change. They are also used to compress data to show a wide range of data in a small space. A 5-cycle log graph can show a range of 100,000 numbers—difficult to do on an arithmetic graph if you want the graph to show small numbers.

Log scales are used on two types of graphs:

Those which compare a percentage change with an arithmetic change such as time are called *semi-log* or *single-axis* graphs. These graphs have a logarithmic scale on one axis and an arithmetic scale on the other axis.

Those which compare percentage change with another percentage change are called *log-log* graphs or *dual-axis* graphs. These graphs have logarithmic scales on both axes.

HOW TO USE LOG GRAPHS

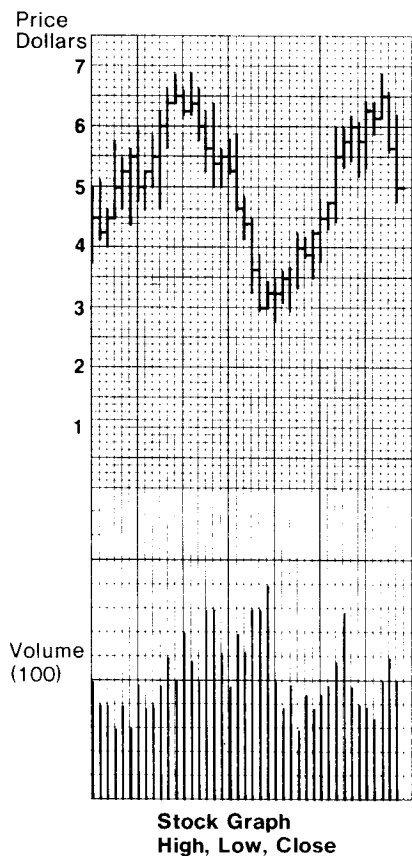
To use log graphs, first examine the range of data to determine the number of decimal orders of magnitude of change and thus the number of logarithmic cycles you will need.

Decide what number you wish to start with at the bottom of the graph—not zero.

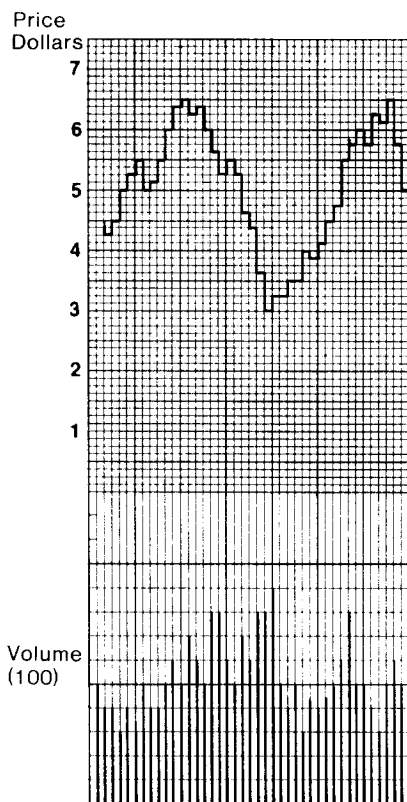
Write that number at the bottom tick mark for the first cycle. Write 10 times that number at the top tick mark of the second cycle, 100 times that number at the top tick mark of the third cycle, and so on.

Repeat for the other axis of the graph if it is also a log axis. If not, the spacing between grid lines on that axis will be uniform and you must assign units based on an arithmetic progression.

When tracing a graph from log paper, major accent lines must be retained and identified. Unaccented or minor accent lines may be replaced by tick marks or eliminated.



Stock Graph
High, Low, Close



Dow Theory

STOCK-MARKET GRAPHS

Stock-market graphs often have two grids with a common time scale on the X axis: one showing price and the other showing volume. Volume is shown as a series of vertical bars along the bottom of a small graph accented in tenths. Because stock is traded in eighths of a point, the upper grid is accented in eighths. There are several ways to plot price on this grid. Most common is a vertical bar between the high price and the low price of the day, with a horizontal tick to the right showing the closing price for that day.

Individual stocks may be plotted on arithmetic grids, or on semi-log grids to show percentage change. When a stock and an indicator such as the Dow-Jones average are plotted on the same grid, a semi-log grid must be used because relative change is implied.

DOW THEORY

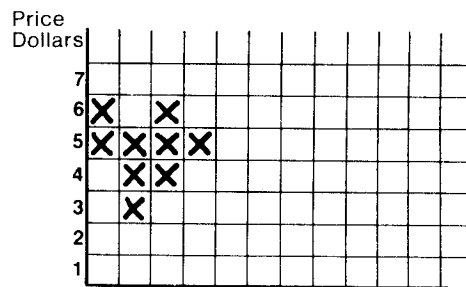
Followers of the Dow Theory use a step chart to indicate price change. They plot closing prices as a series of horizontal lines. These lines are connected by vertical lines forming a series of steps. The result is similar to the previous method, but does not show price extremes during the day.

POINT-AND-FIGURE GRAPHS

Point-and-figure graphs use a series of X's to indicate price trend. An X may indicate any price range you choose, for example, 1 point, 7 points or 3 points.

In a 1-point graph, the paper is scaled on the Y axis so one square equals one point. An X is placed on the square showing the present price. When the price has advanced or declined to the next even full point, a second X is placed in the same column above or below the last X. When the price changes in the other direction by one full point, an X is placed on the stock price in the next column to the right. X's are continued in this column until the price changes in the other direction. Some analysts use X's in the columns when price is increasing and O's when the price is decreasing.

Point-and-figure graphs are used to show stock-price trends. They do not show volume, nor do they show the price on any given date.



Point-and-Figure — One Point

LINES

Lines connecting data points should be bold enough to stand out on the graph. Lines should be identified on multiple-curve graphs.

PROBABILITY GRAPHS

A probability graph shows what has occurred in the past and what will probably happen in the future, assuming the past is a model of the future.

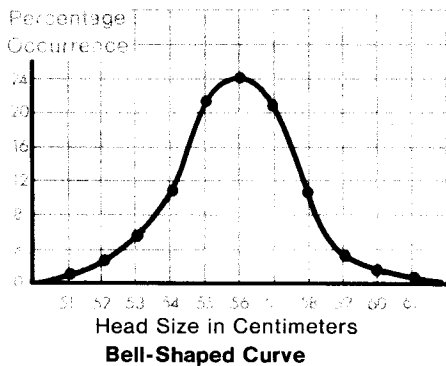
The principle of the probability graph is based on the theory that plotting any series of natural occurrences will form a *normal distribution* or "bell-shaped" curve. For example, if you measured the circumference of the heads of a large group of boys from 16- to 19-years old, you would find a distribution similar to that shown by Winfield S. Hall in his article *The Evaluation of Anthropometric Data*.*

* Page 1646, Vol. 37, *Journal of the American Medical Association*.

HEAD SIZES OF 1071 BOYS AGES 16 TO 19

Head Circumference (cm)	Number of Boys	Percent of Total	Cumulative Percent
51	4	.0037	.0037
52	23	.0214	.0251
53	59	.0550	.0801
54	108	.1008	.1809
55	224	.2092	.3901
56	257	.2400	.6301
57	230	.2148	.8449
58	110	.1027	.9476
59	38	.0355	.9831
60	16	.0149	.9980
61	2	.0020	1.0000
Total	1,071		

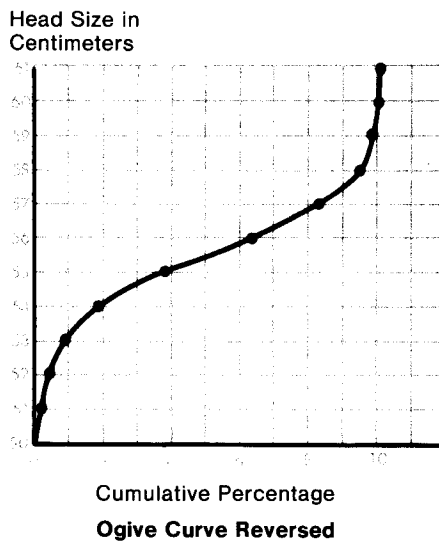
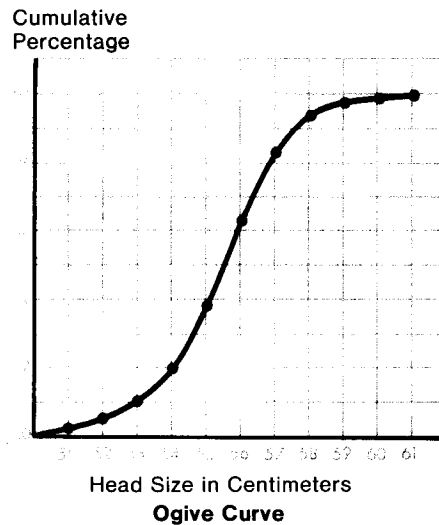
The Bell-Shaped Curve—When a curve is drawn plotting the number, or percentage occurrence, of boys with each head size, it forms a "bell-shaped" curve as shown in the illustration.



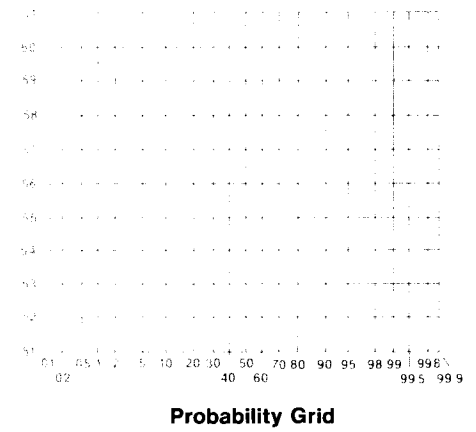
By dividing the number of boys with each head size by the total

number of boys, you will arrive at the percentage distribution shown in the table. Obtain the cumulative percentage for each head size by adding the percent of total for each size to all the percent of totals for all smaller sizes. This is shown in the last column of the table.

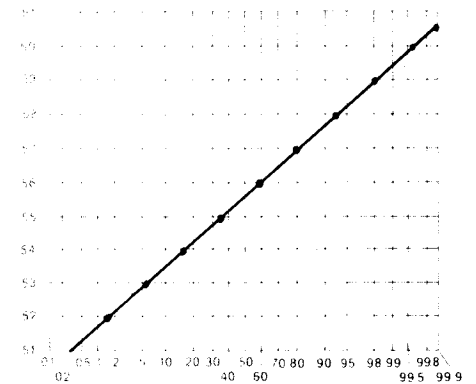
Ogive—When this *cumulative percent* is plotted on the X axis, it forms an S-shape curve called an *ogive*. Plotting this curve with the cumulative percentage on the X axis reverses the curve.



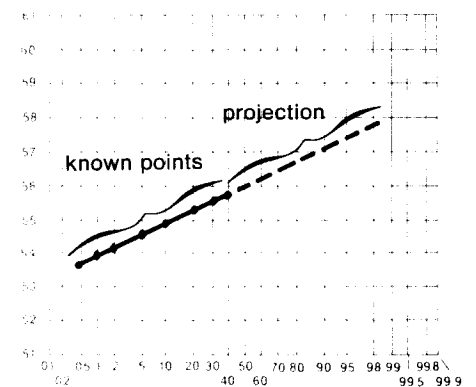
Probability Grid—If you draw a grid in which the Y axis is an arithmetic scale, and the X axis shows the distance between percentages, you have a grid which will produce a straight line when the ogive is drawn. This grid is similar to that of the probability papers in this book.



When you plot a series of known points on this grid and they form a straight line, this line can be projected to estimate the probability of future occurrence.



Projection of known data on probability grid to predict occurrences



The accuracy of this projection will depend on how straight the line is, and the size of the data sample. More information about this subject can be found in any book on statistics under *probabilities*, *standard deviation*, *skewing*, and *kurtosis*.

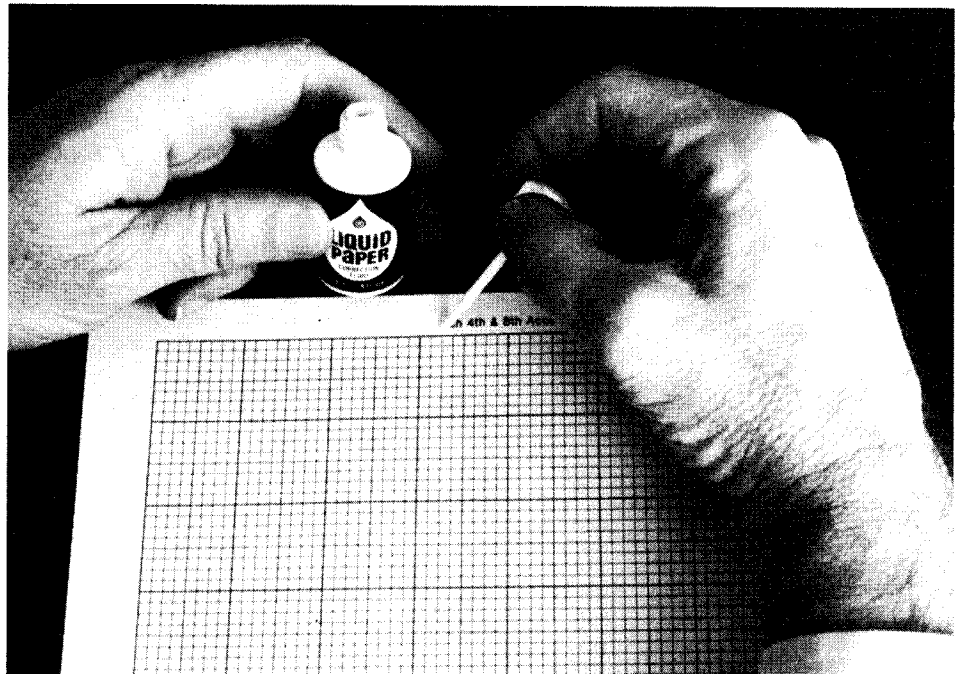
The vertical scale of most probability paper is arithmetic. However, log-scale probability paper is used where the probability on the X axis is the probability of a percentage function (log function) on the Y axis.

ERRORS

Errors are readily corrected and unwanted material eliminated by using opaque white correction fluid that will not reproduce when copies of the graph are made. Two types of correction fluid are available. The most common type for correcting typing allows some copy toner to bleed through the correction. Correction fluid designed for correcting copies allows less toner bleed-through. It may be necessary to apply more than one coat of correction fluid to blank out errors or unwanted material.

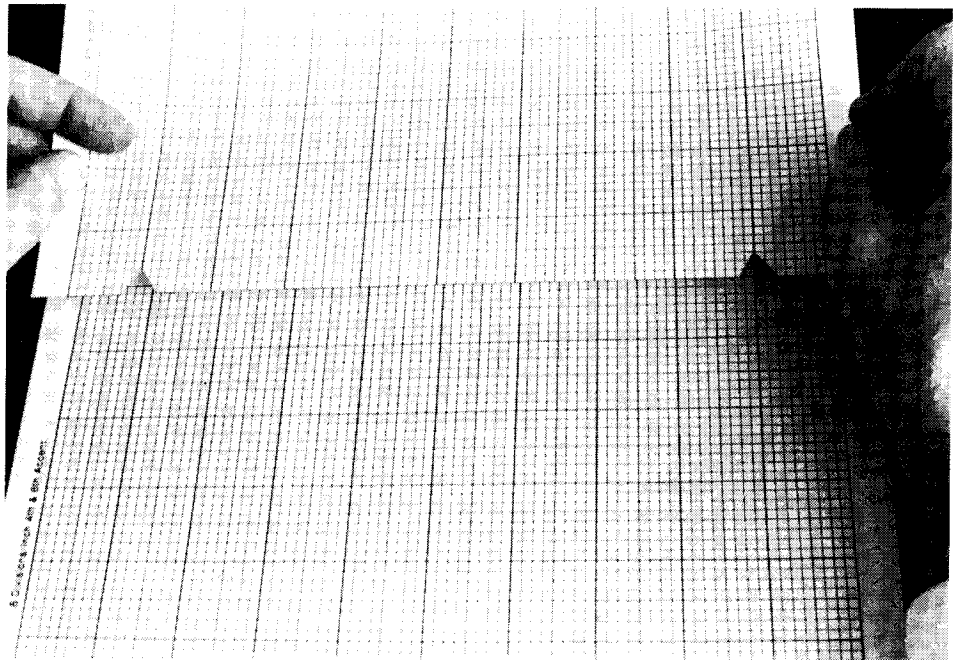
WHEN YOU NEED LARGER PAPER

When a larger sheet of graph paper is required, smaller sheets may be put together by trimming the bottom margin of one sheet and splicing it to the preceding sheet. If the axis is arithmetic, the top sheet may be overlapped and V's cut in the top and bottom of the grid to facilitate horizontal and vertical alignment.



You can also use white correction fluid to cover the title of a graph.

By splicing copies together, you can make any size graph you need.



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


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-  = Time Series
-  = Metric
-  = General

Note: Log-Log Grids are numbered on the top and on the right as a guide and to allow room for labeling on the bottom and to the left.

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1/2 Day by 1/4 Hour

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1 Month by Day (Calendar)

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FRIDAY					
THURSDAY					
WEDNESDAY					
TUESDAY					
MONDAY					
SUNDAY					

Month by Day

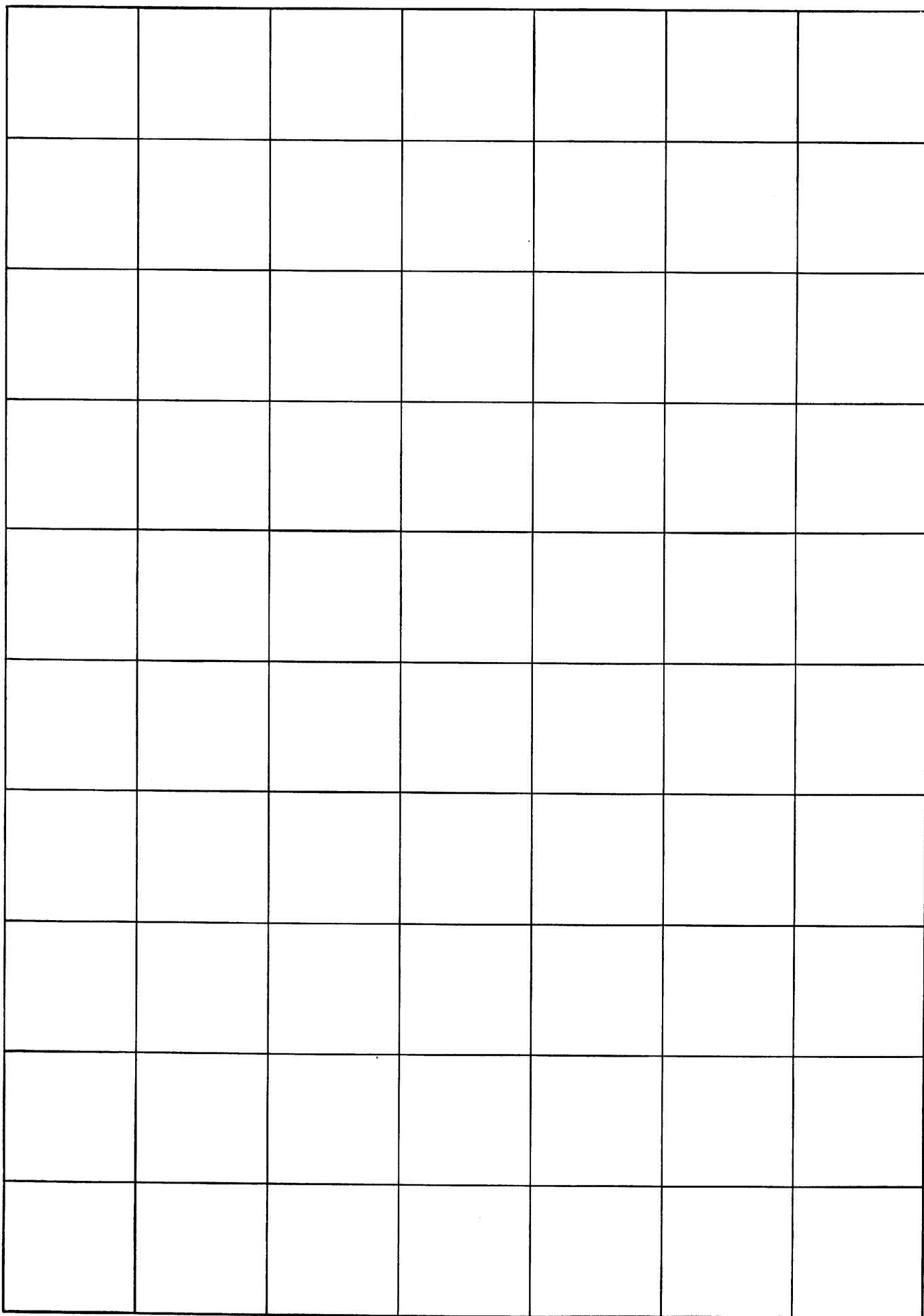
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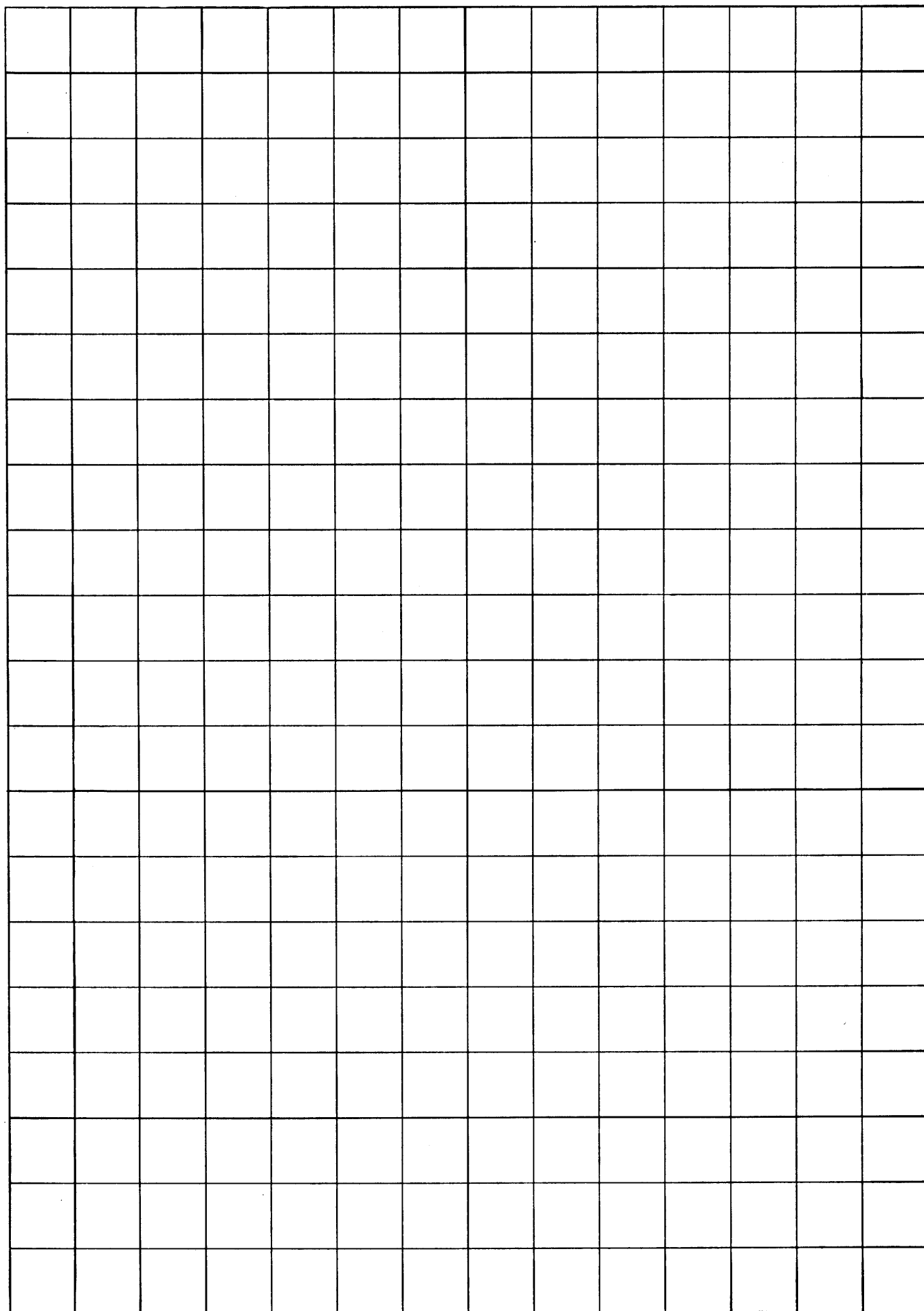
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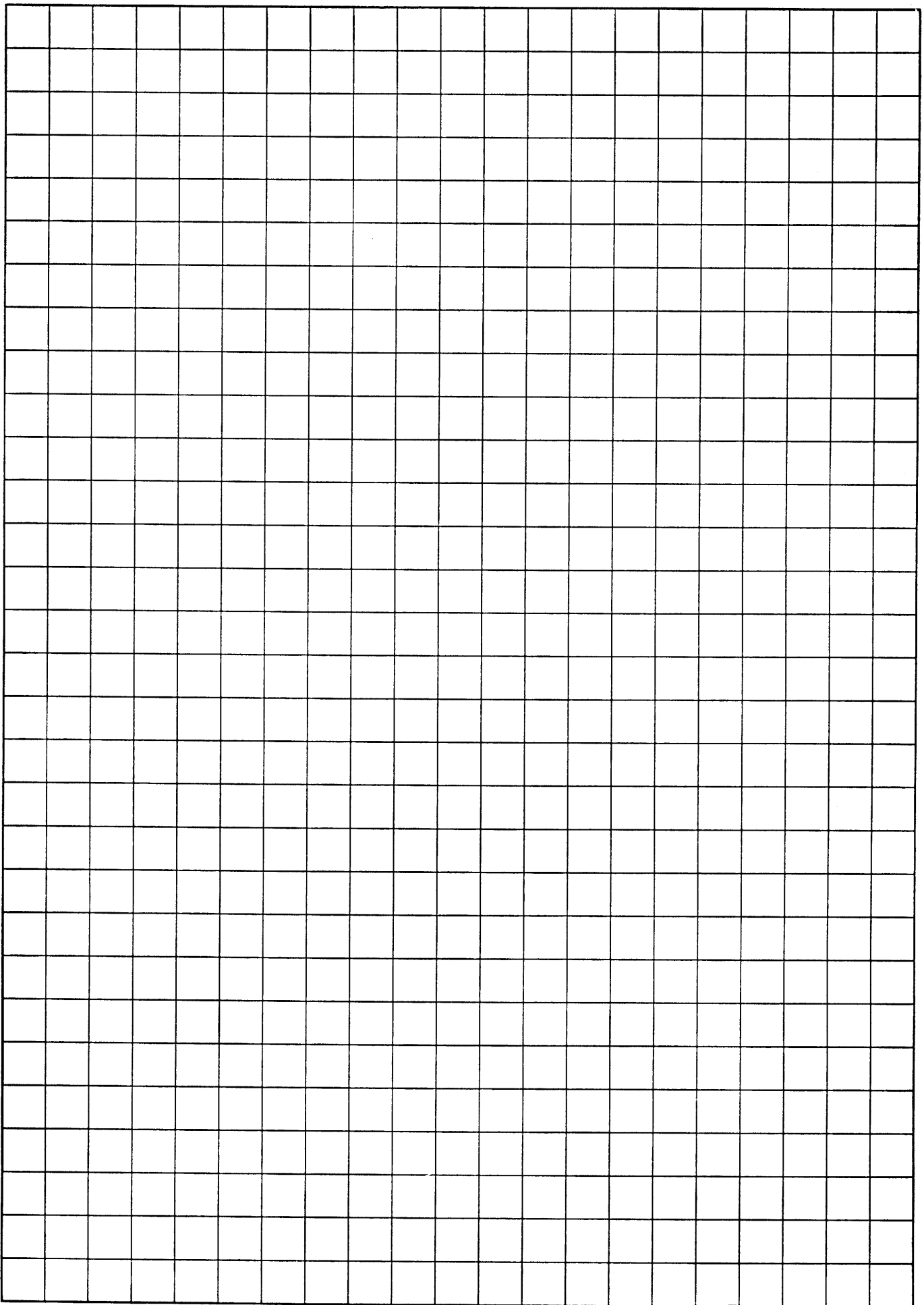
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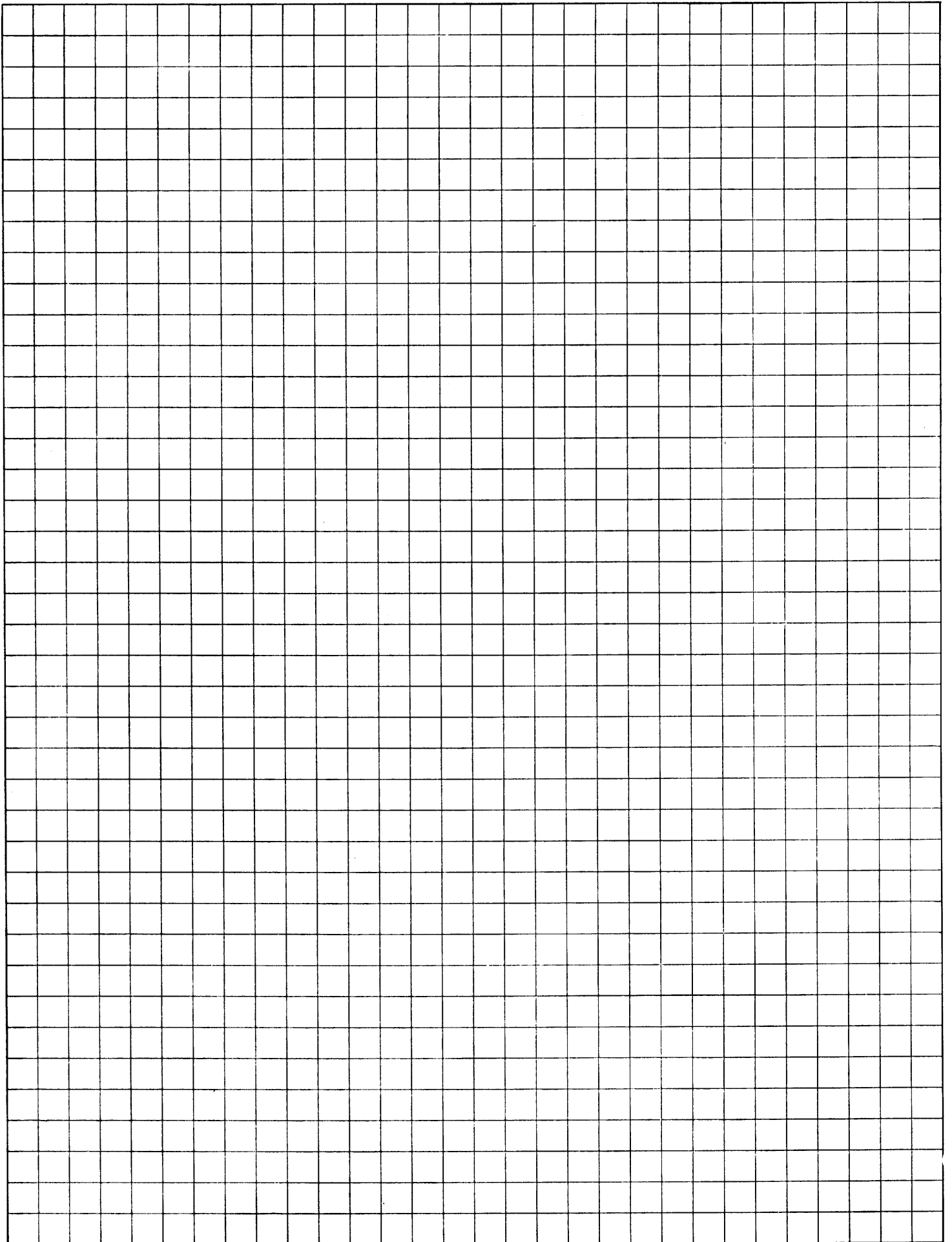
1 Year by Month

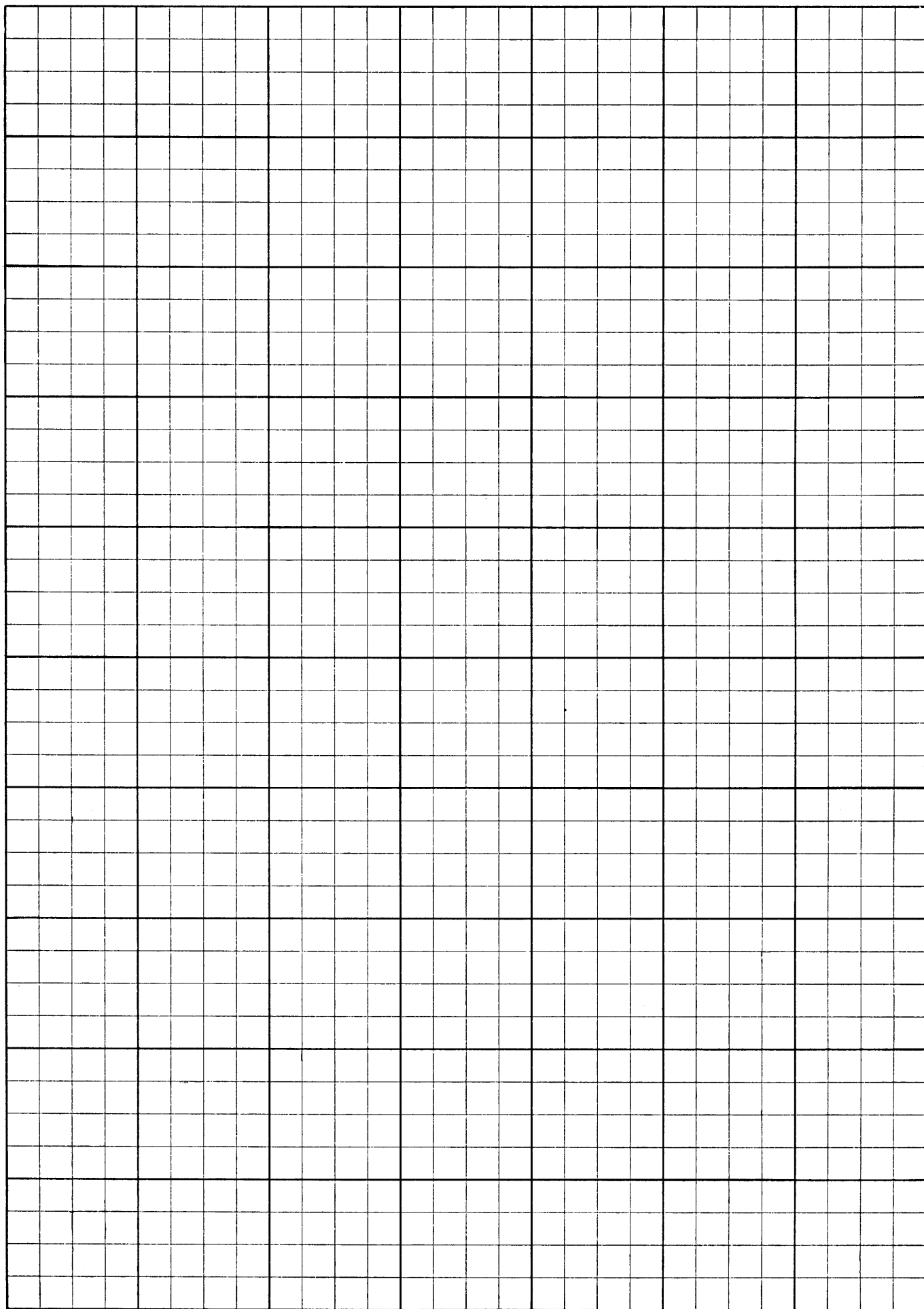
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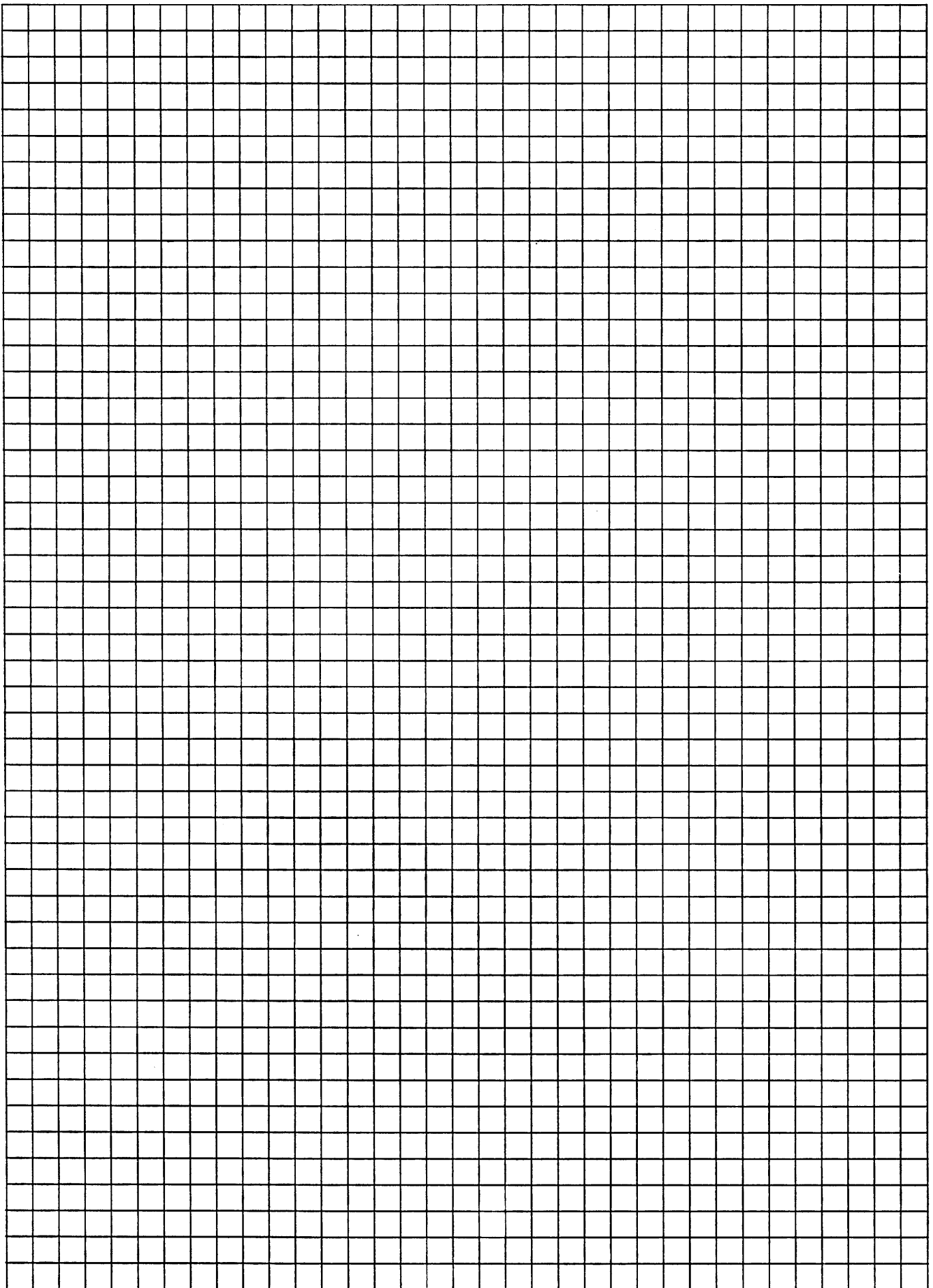


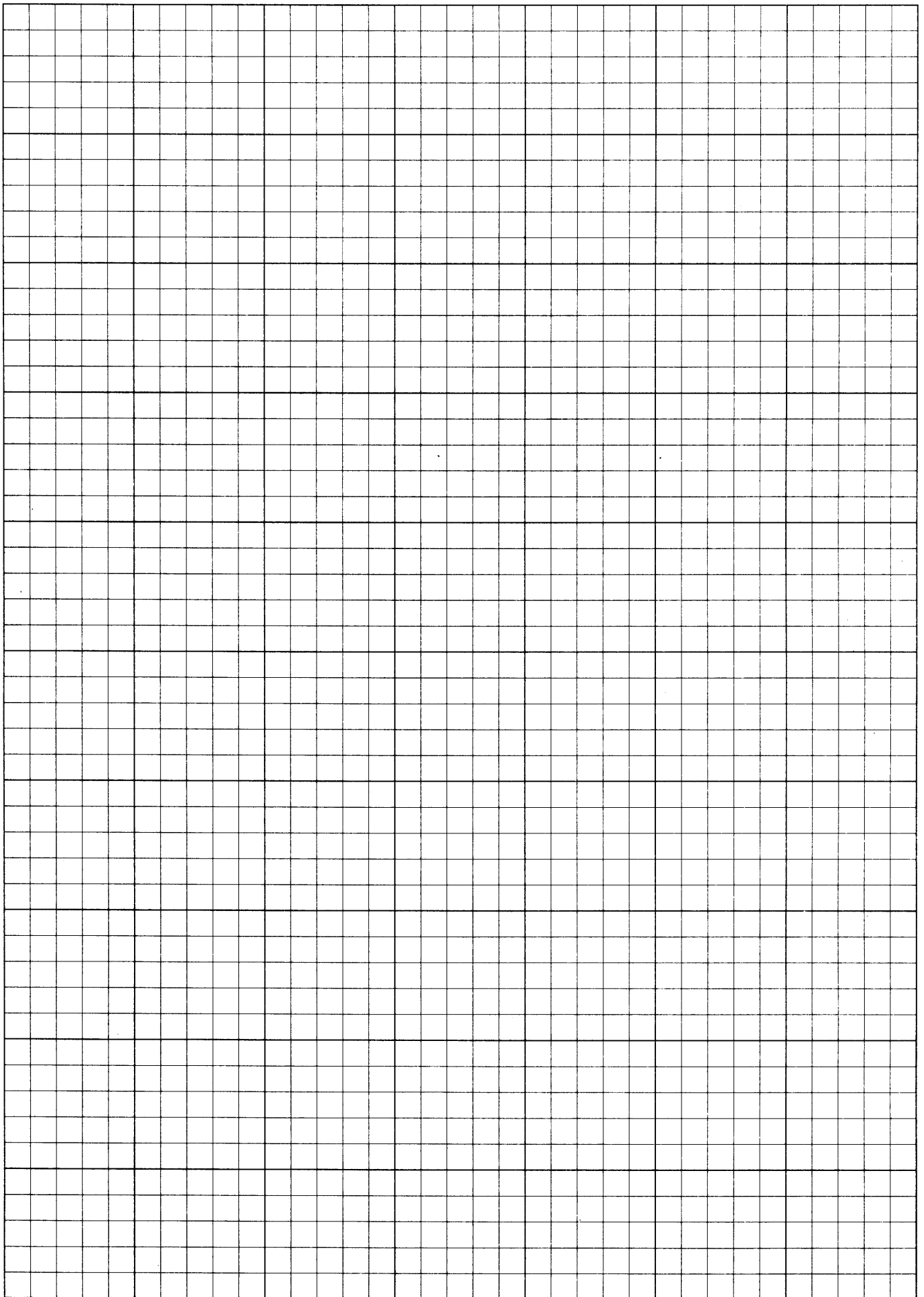


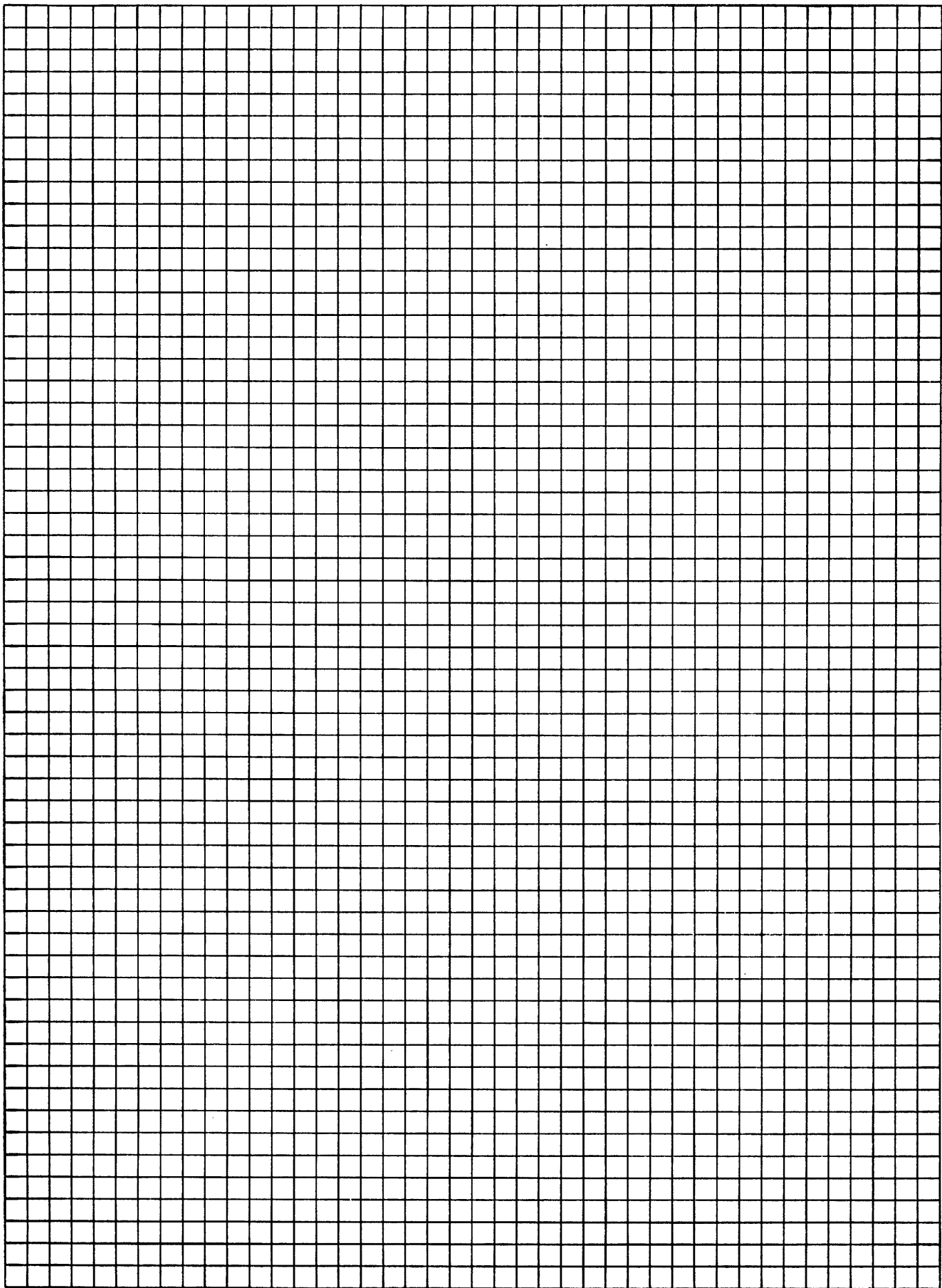


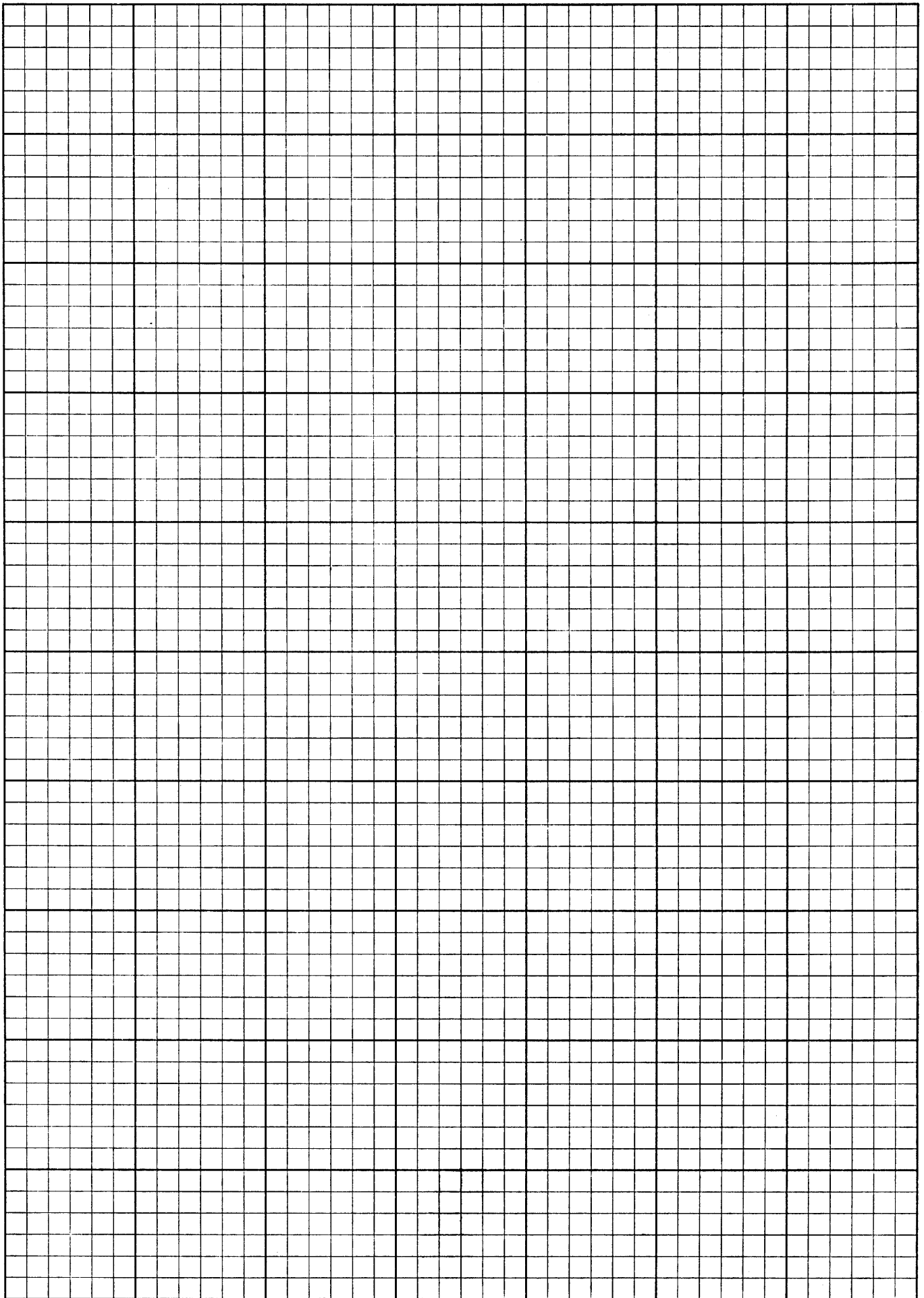


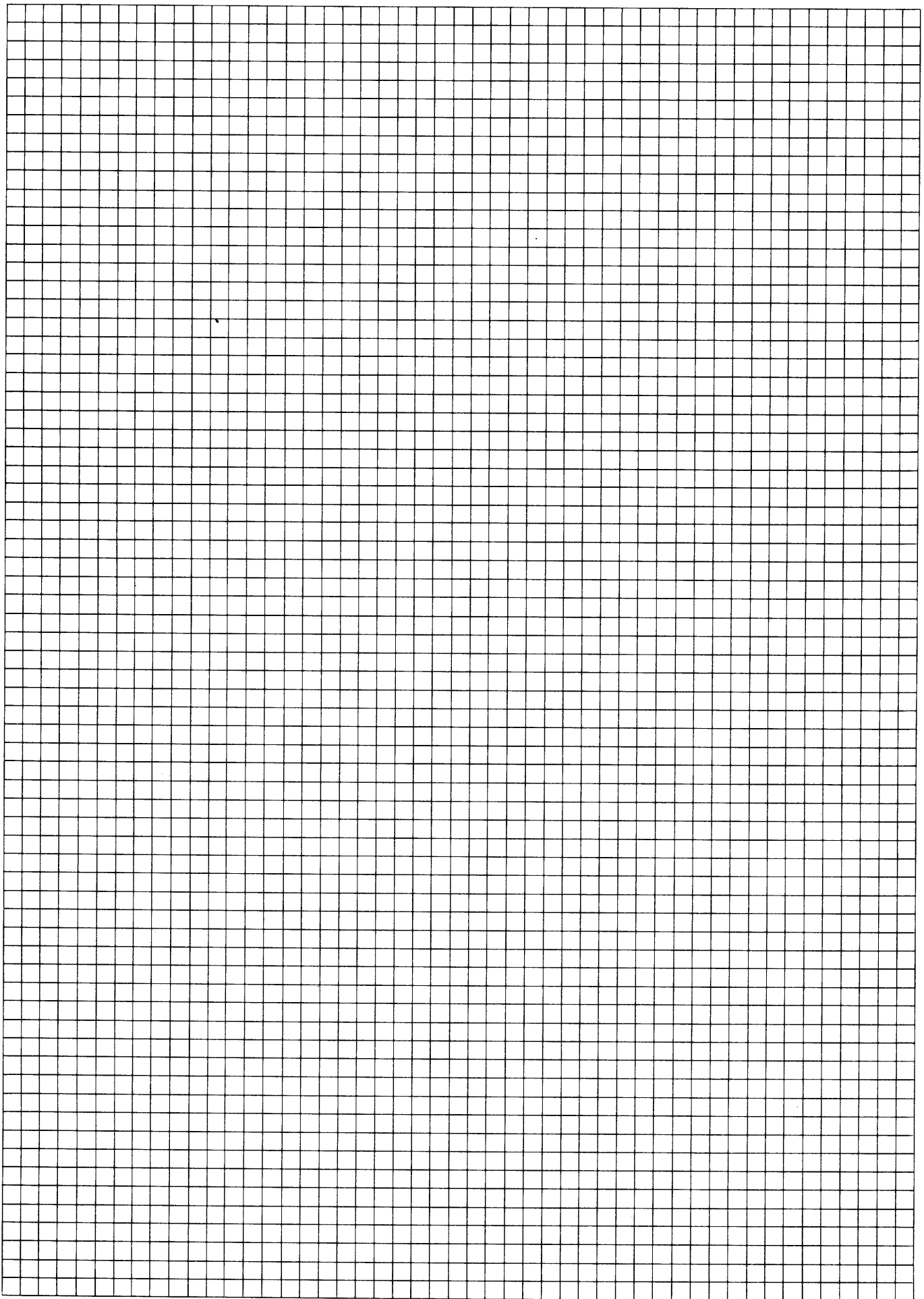


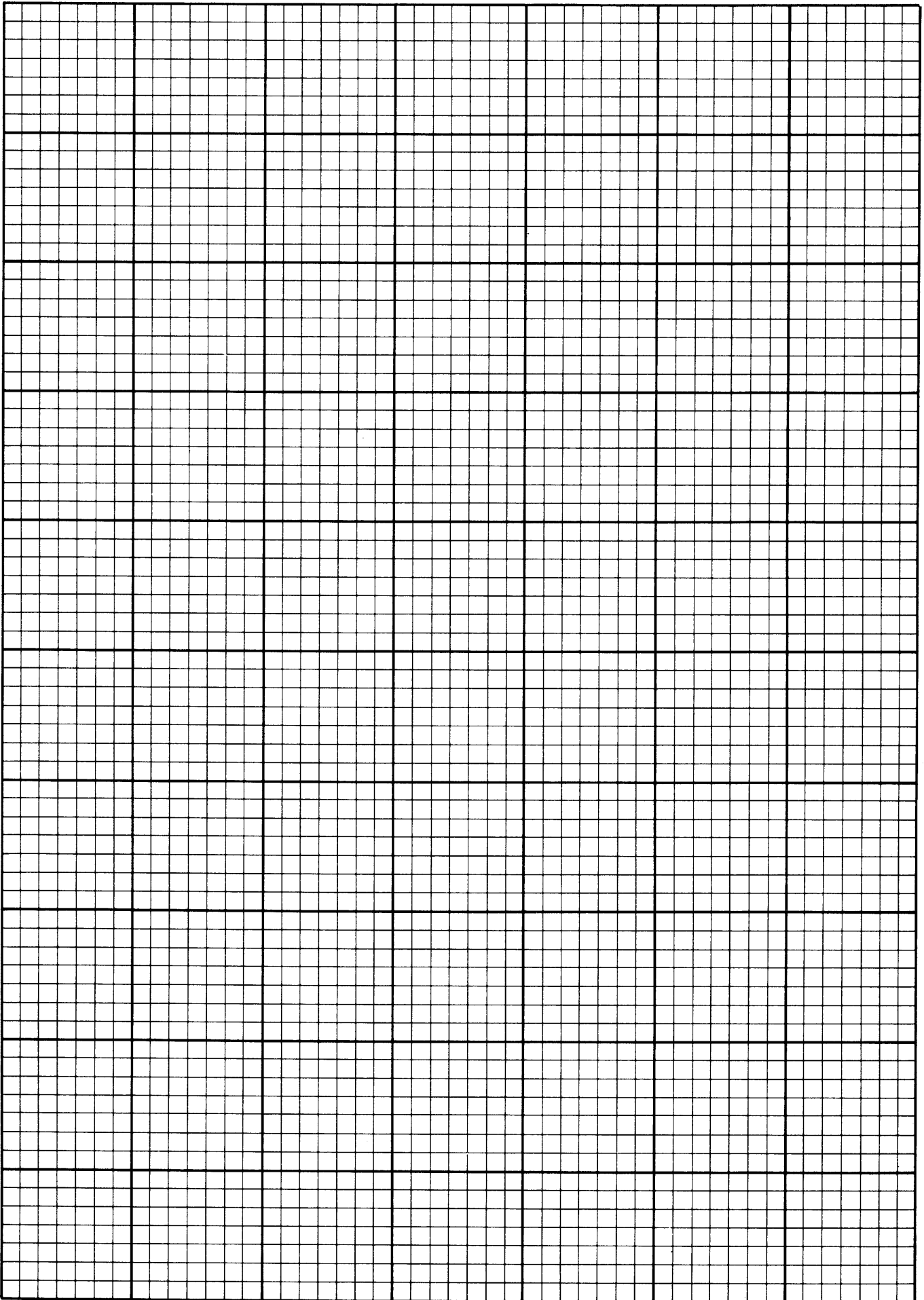


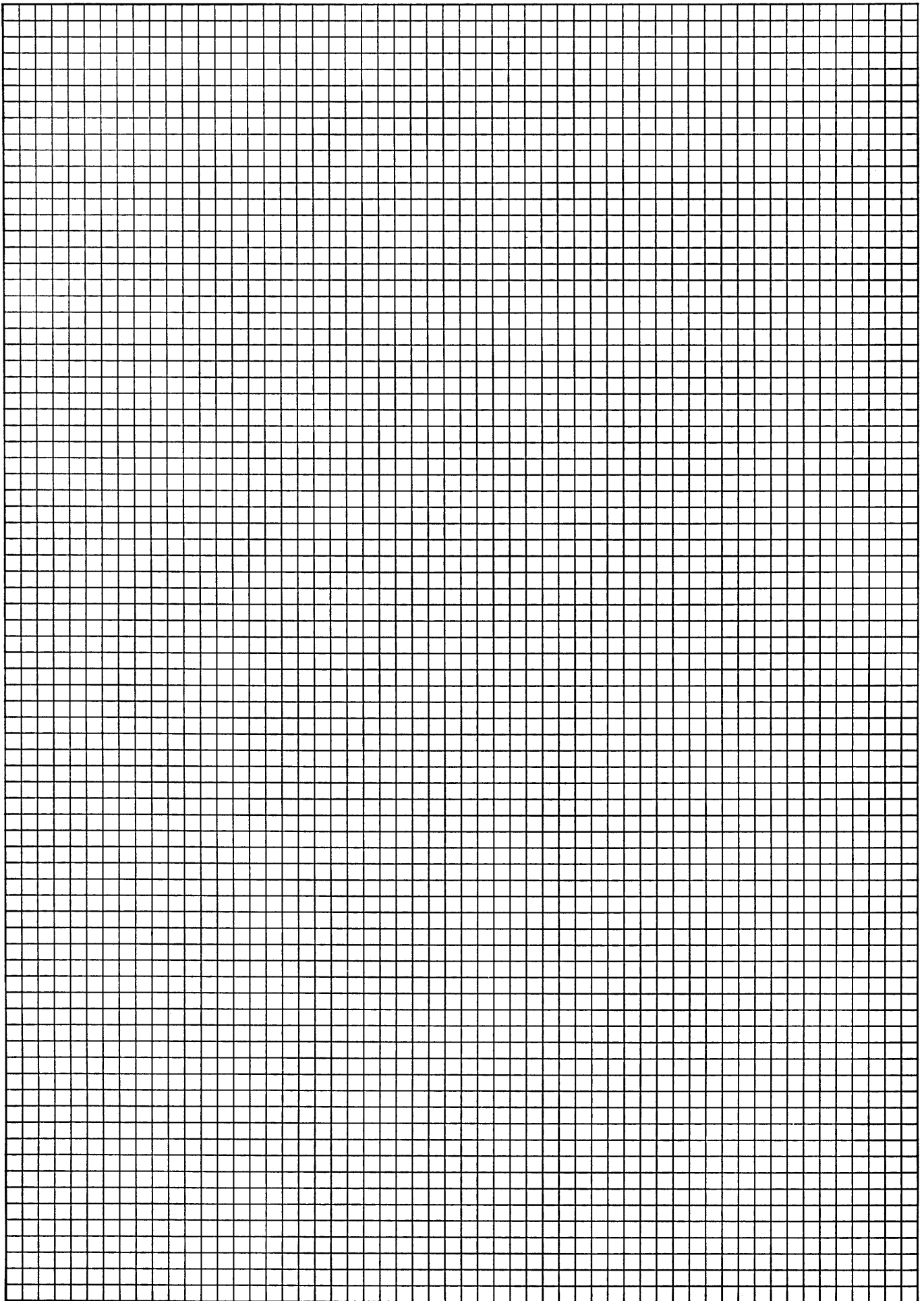


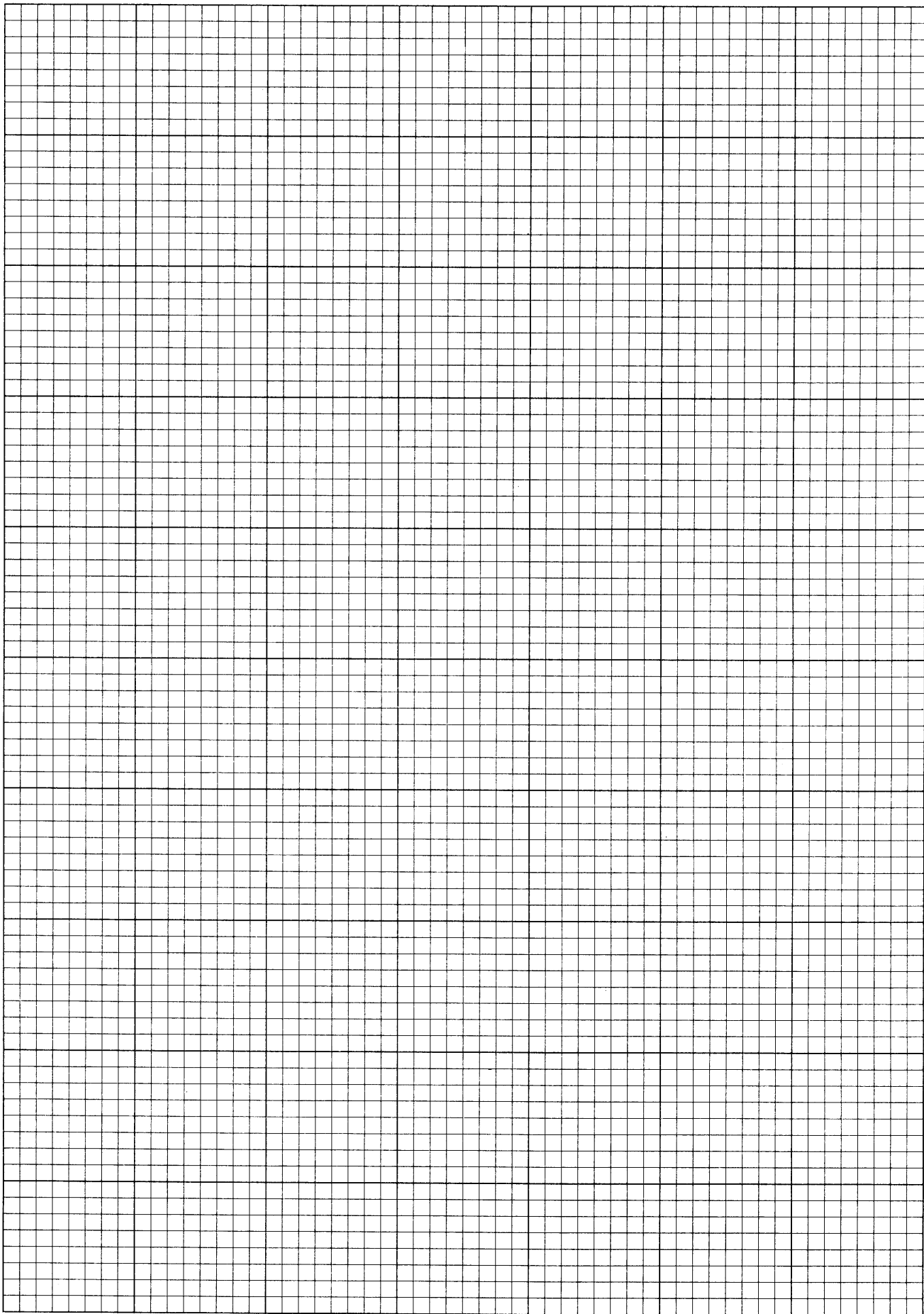


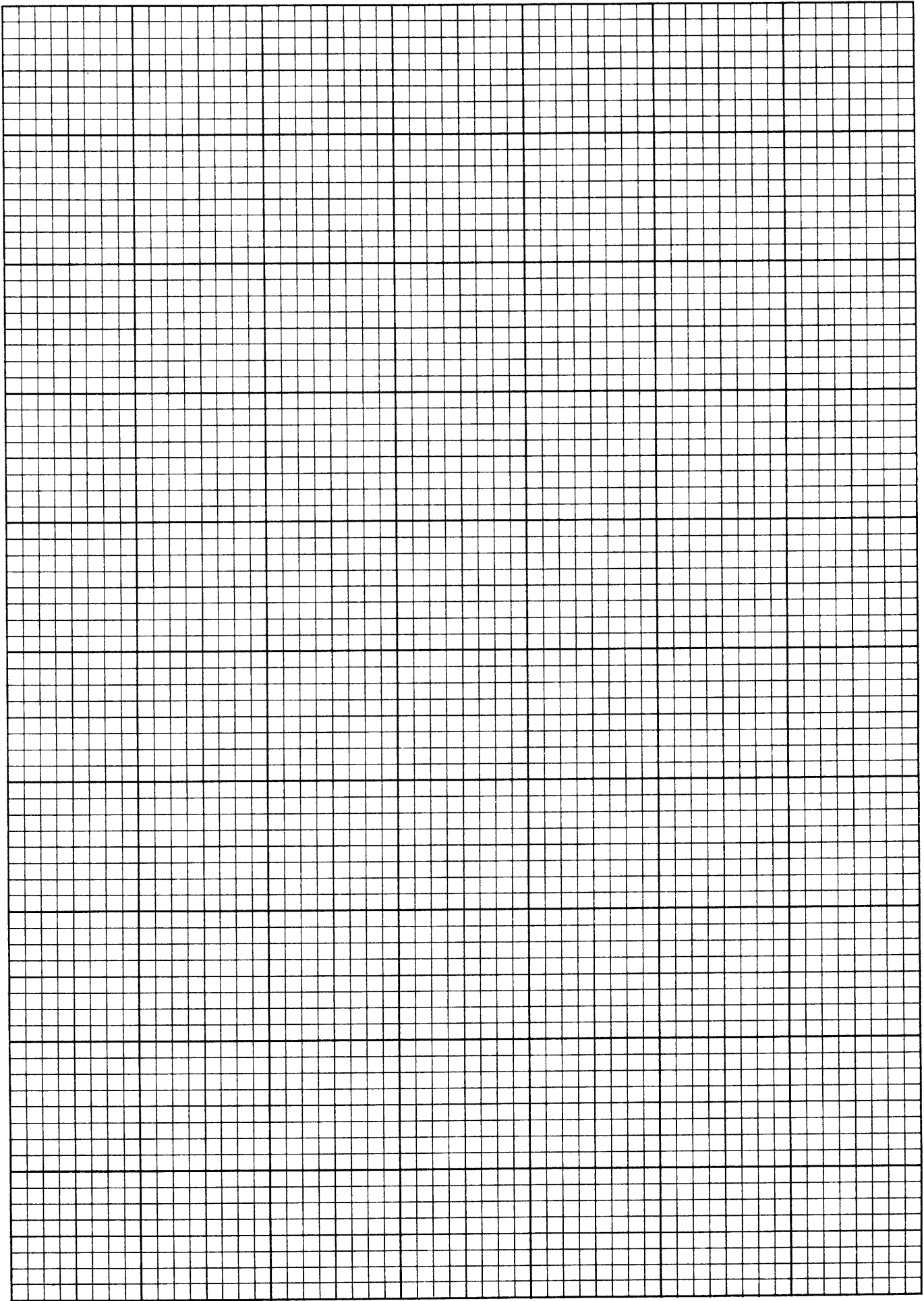


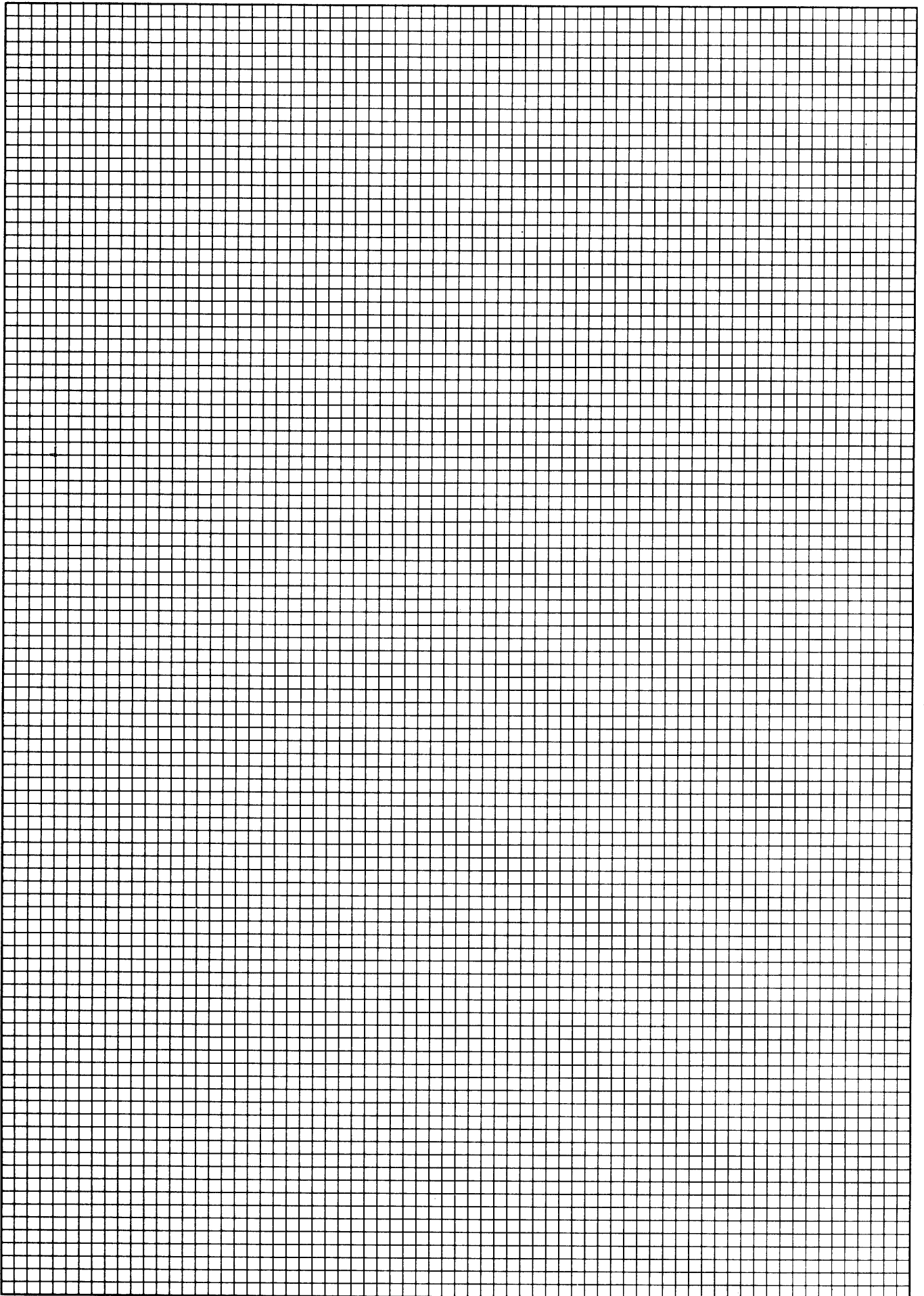


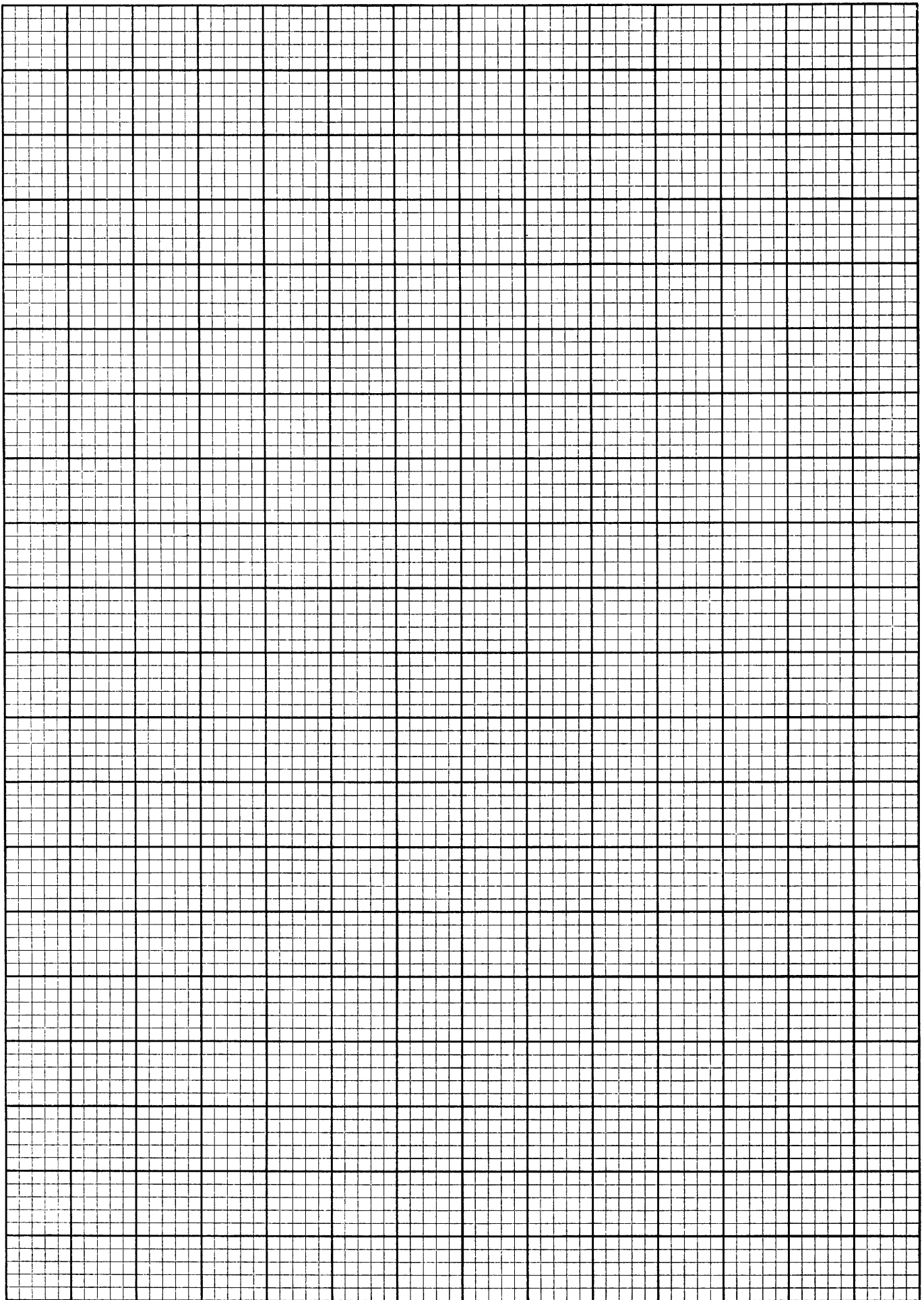


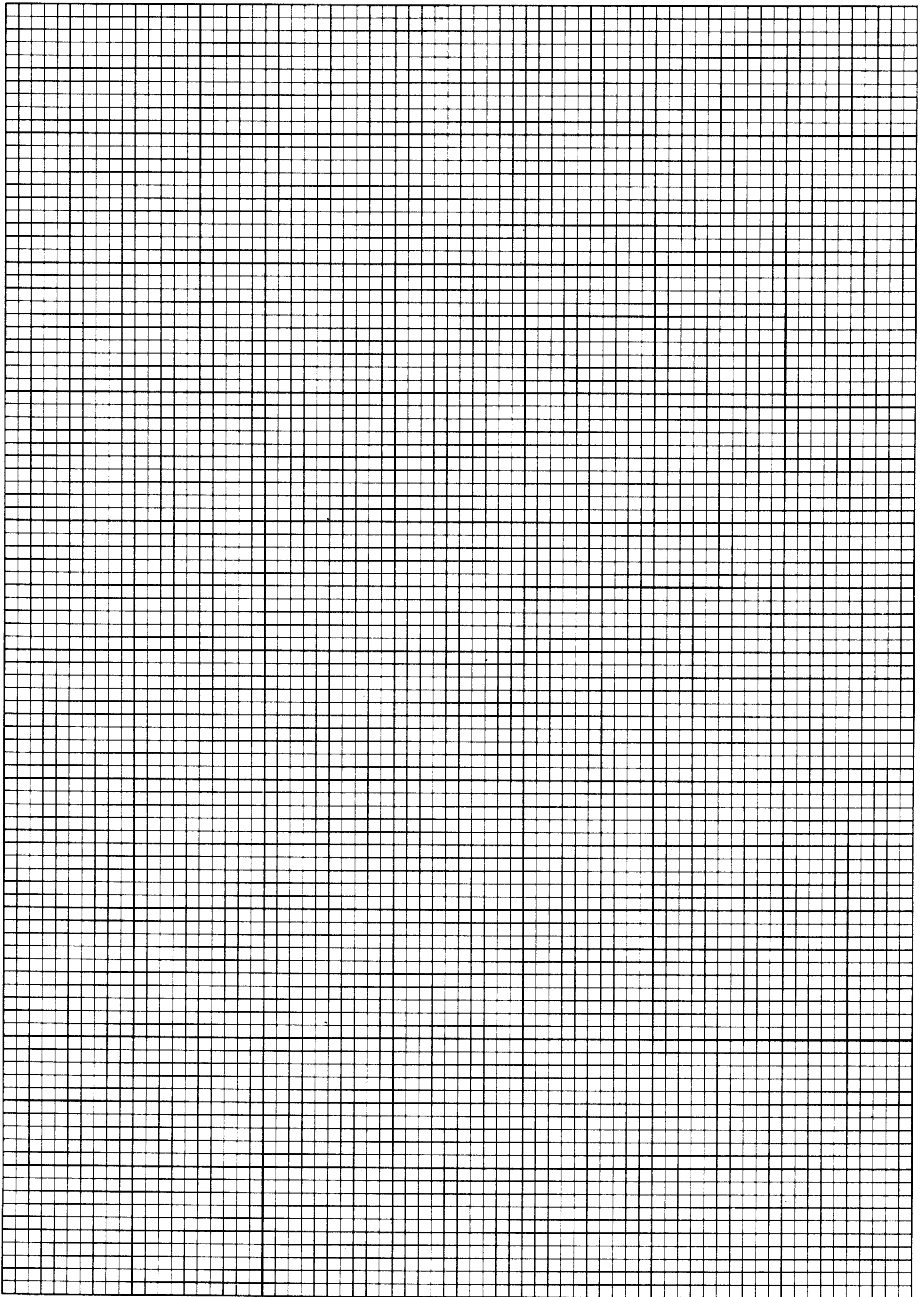


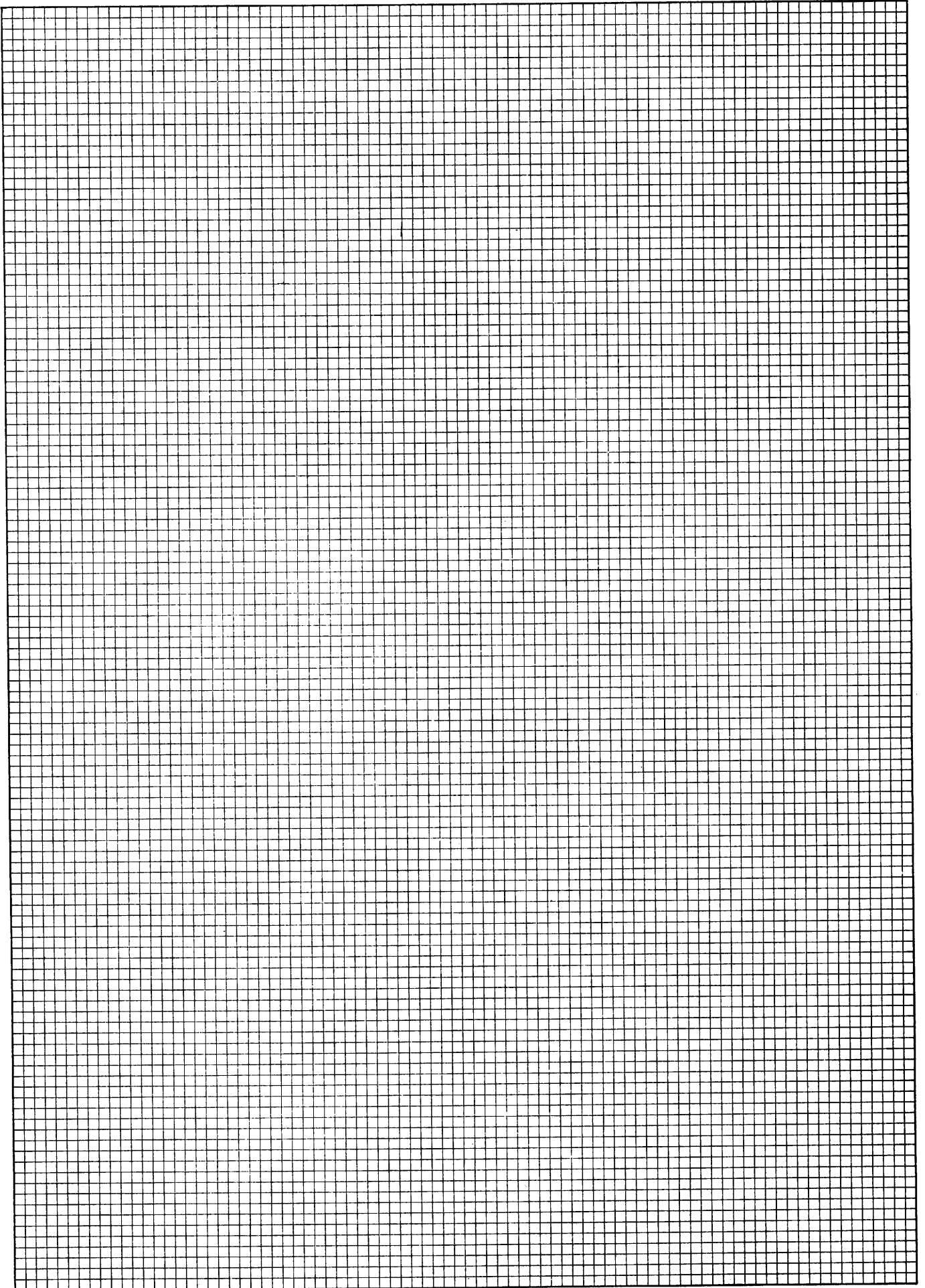


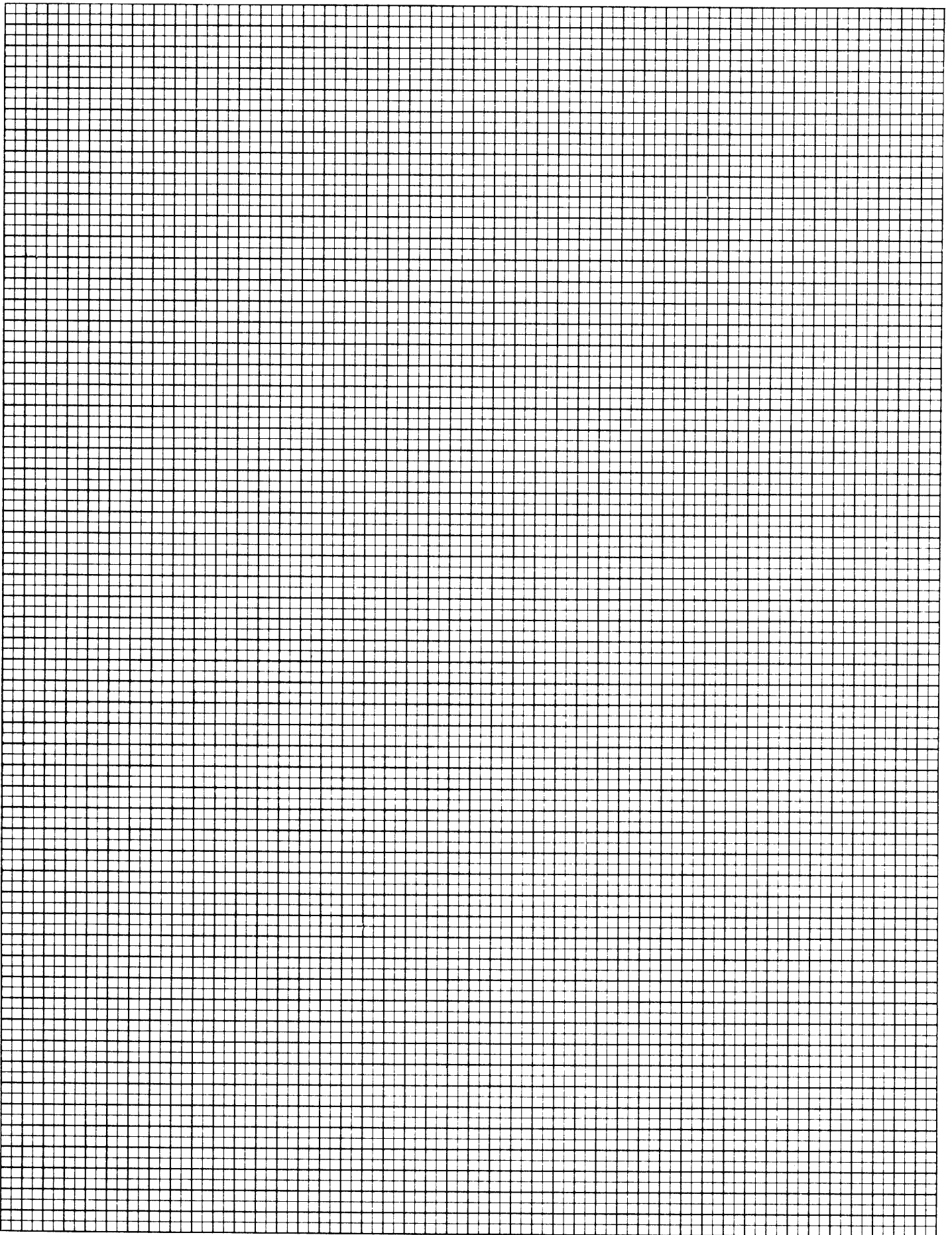


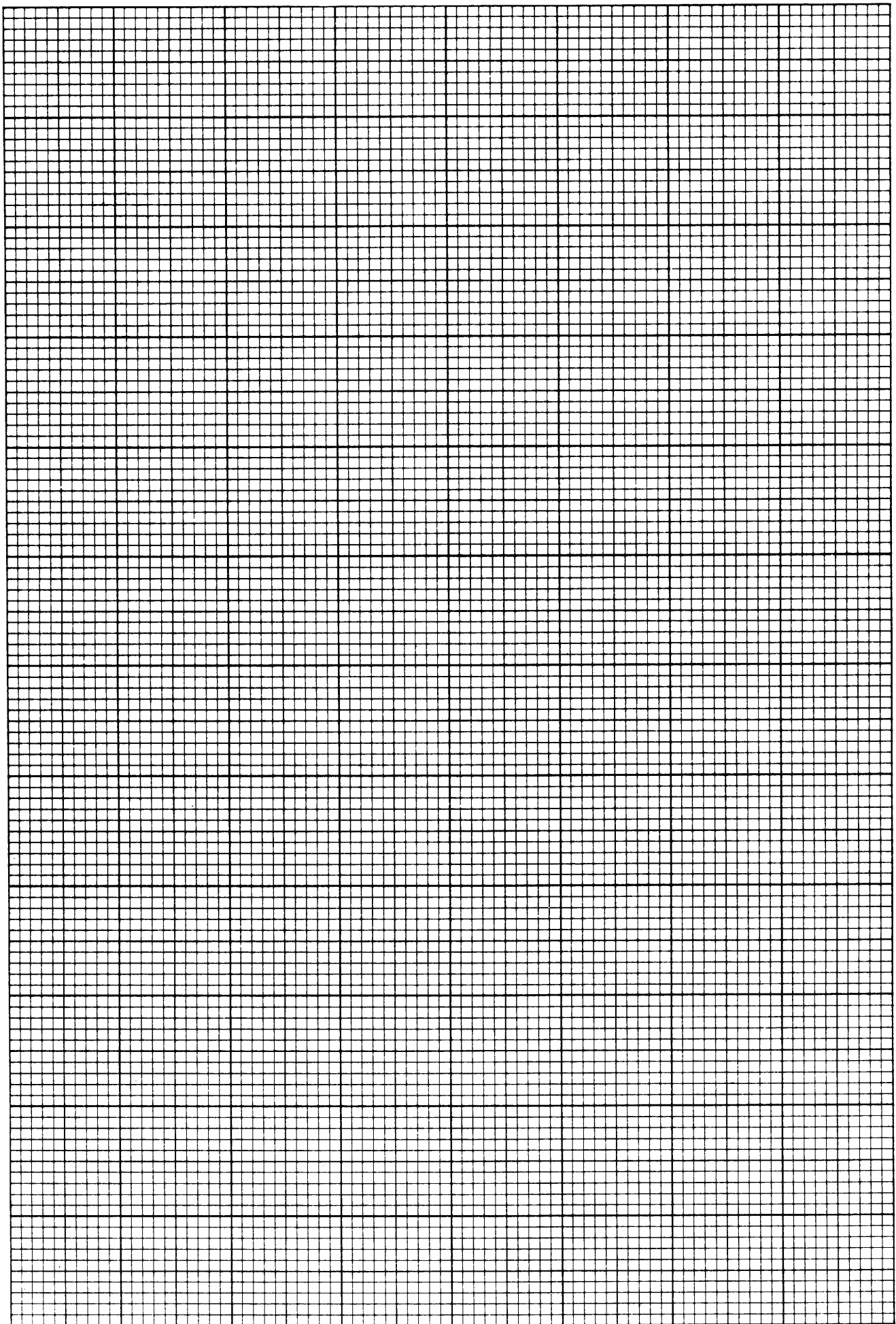


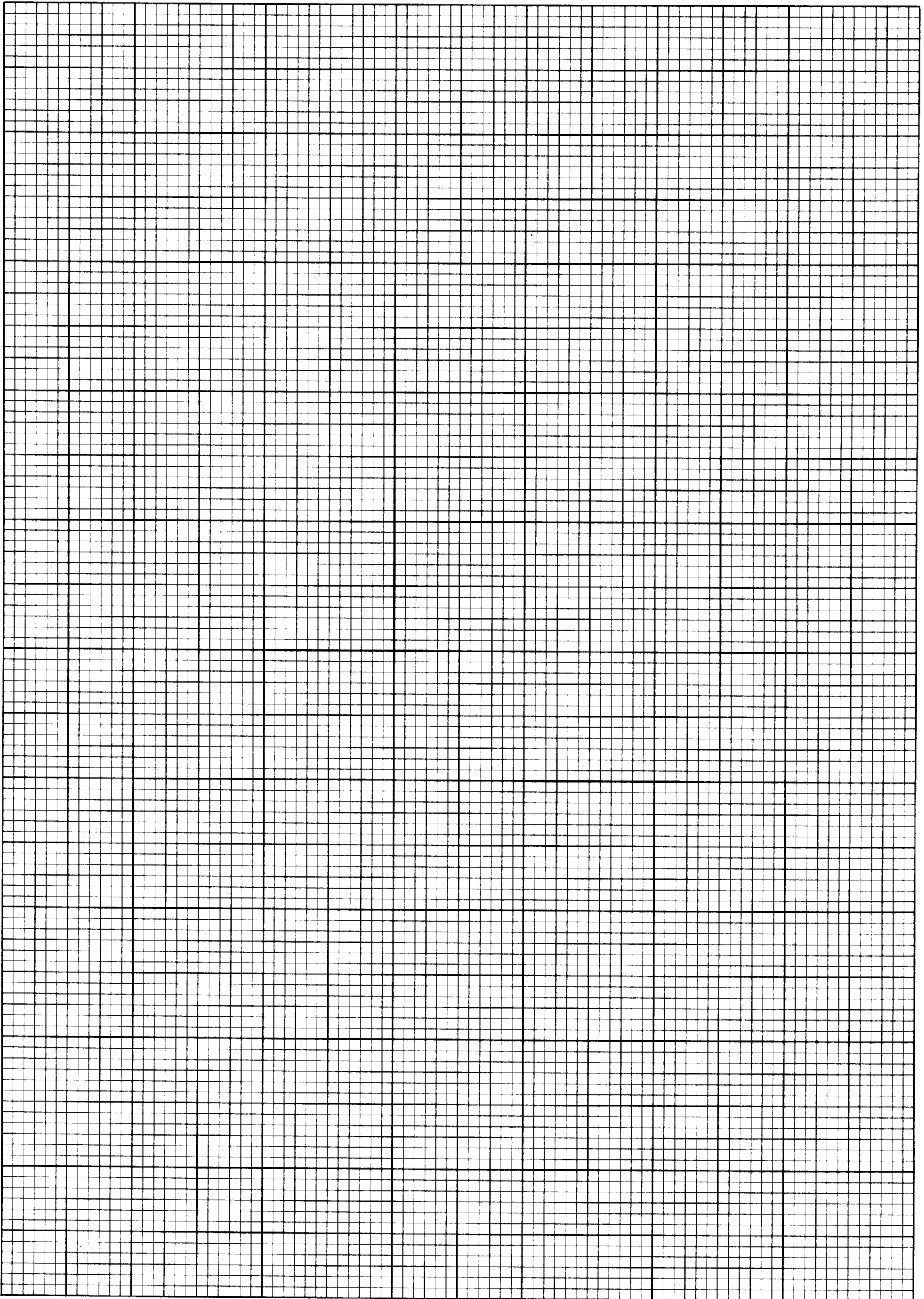


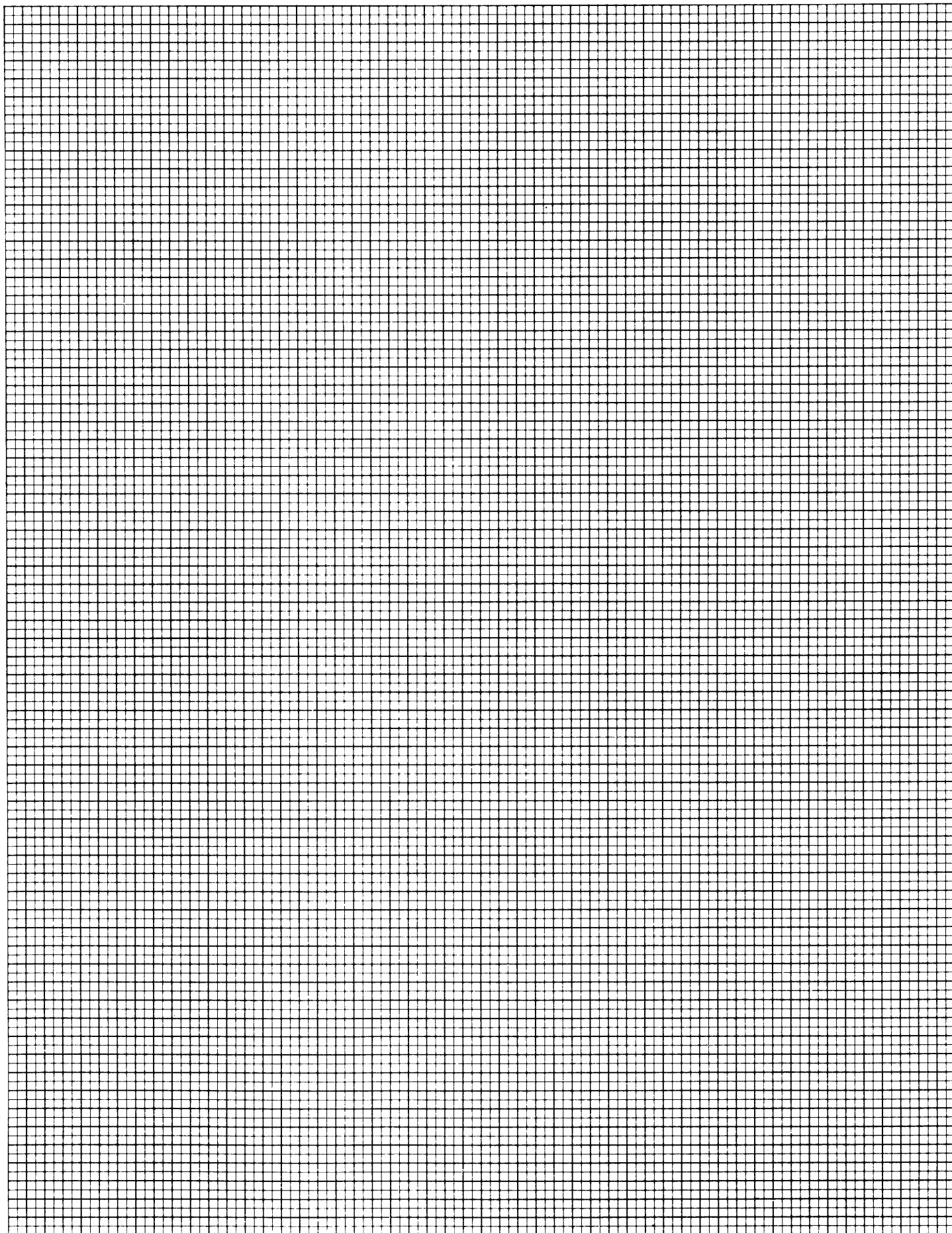


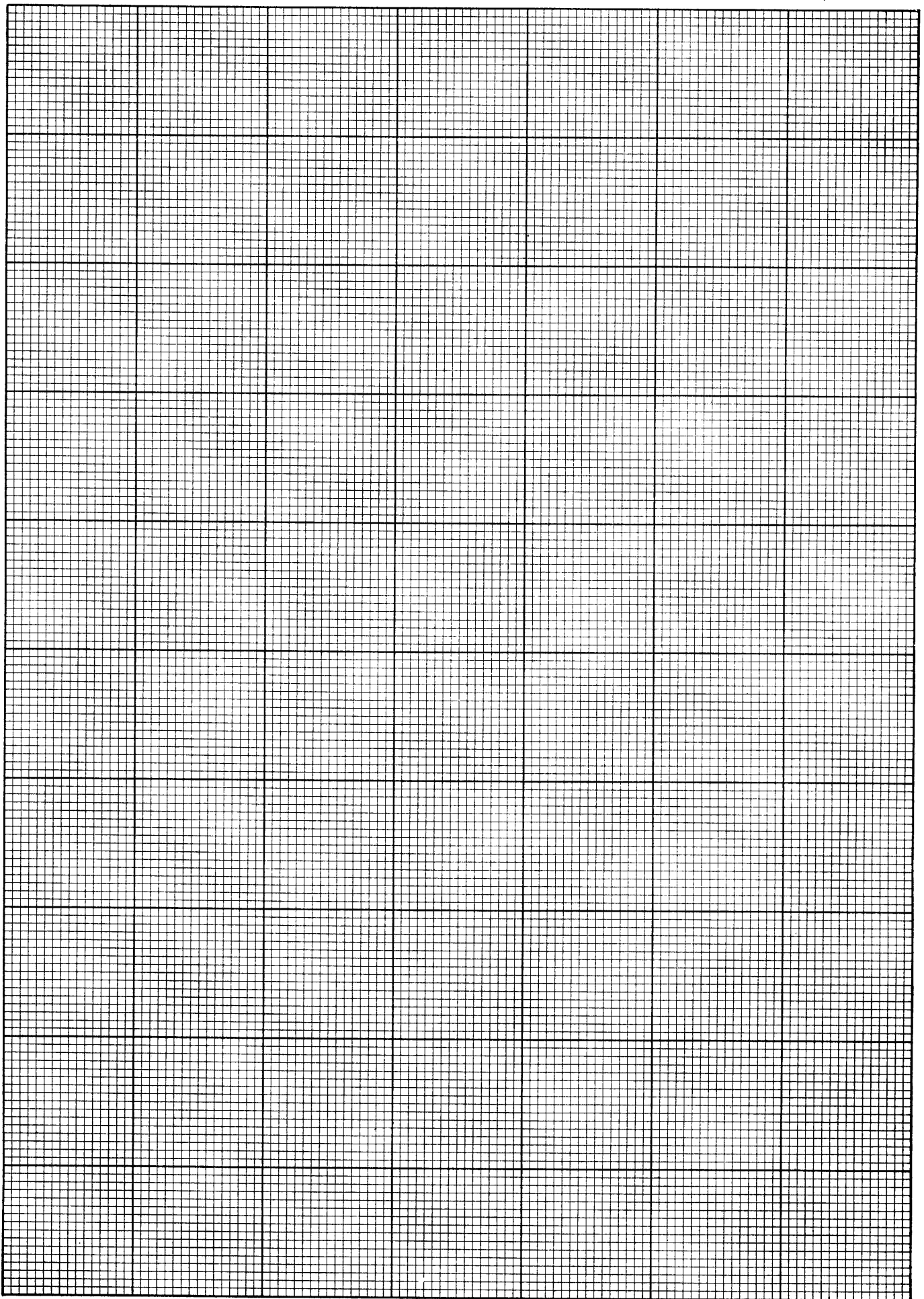


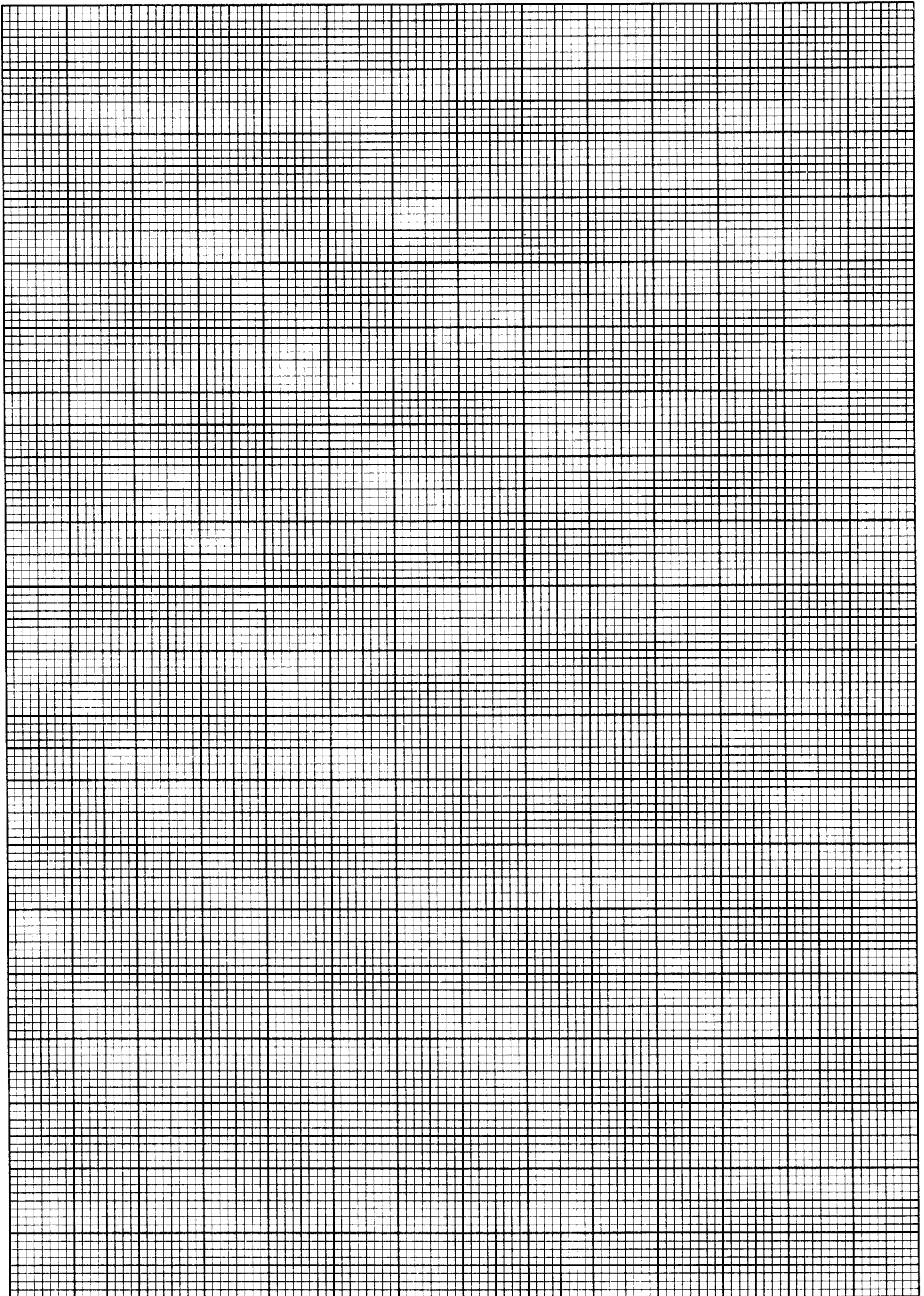


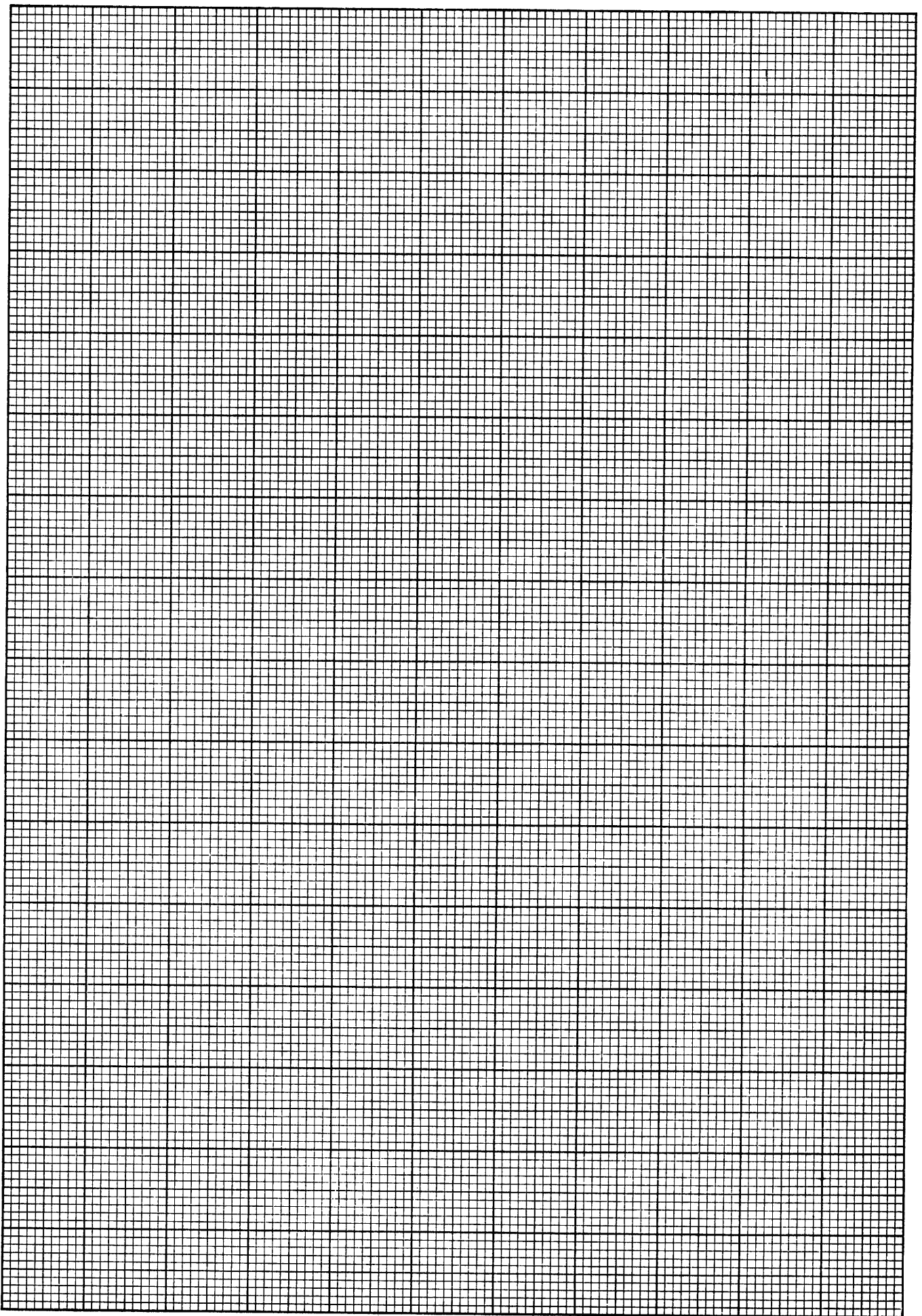


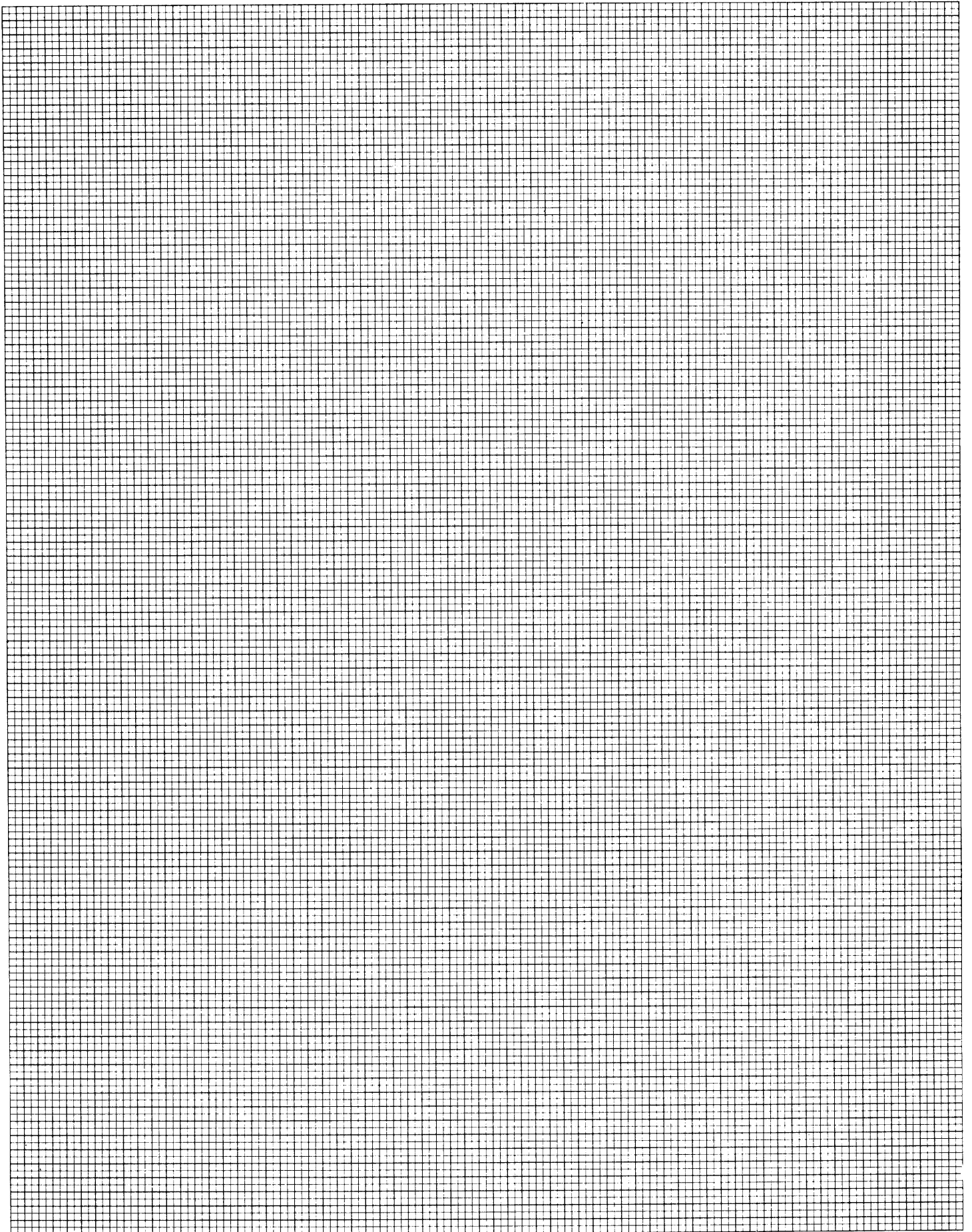


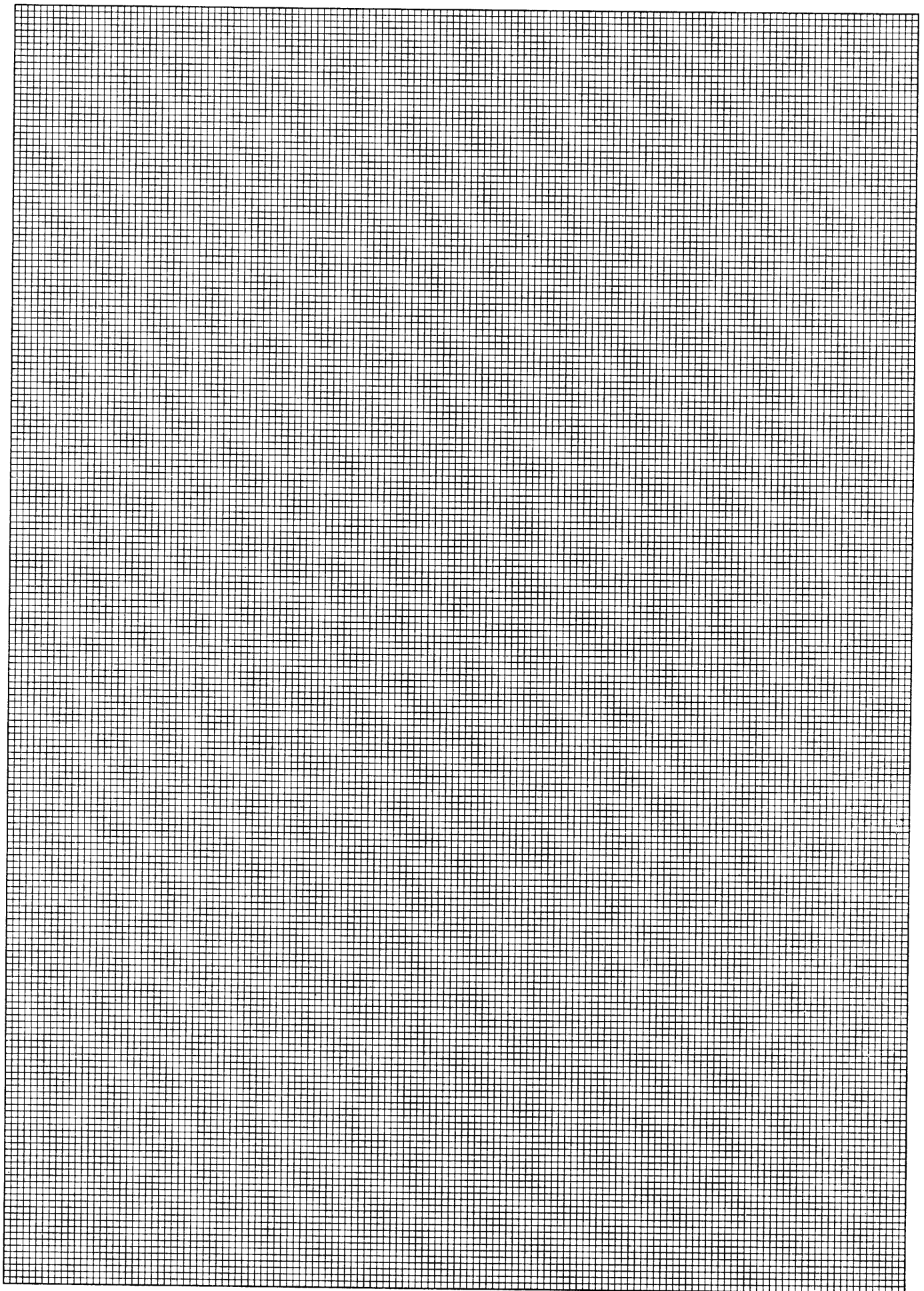


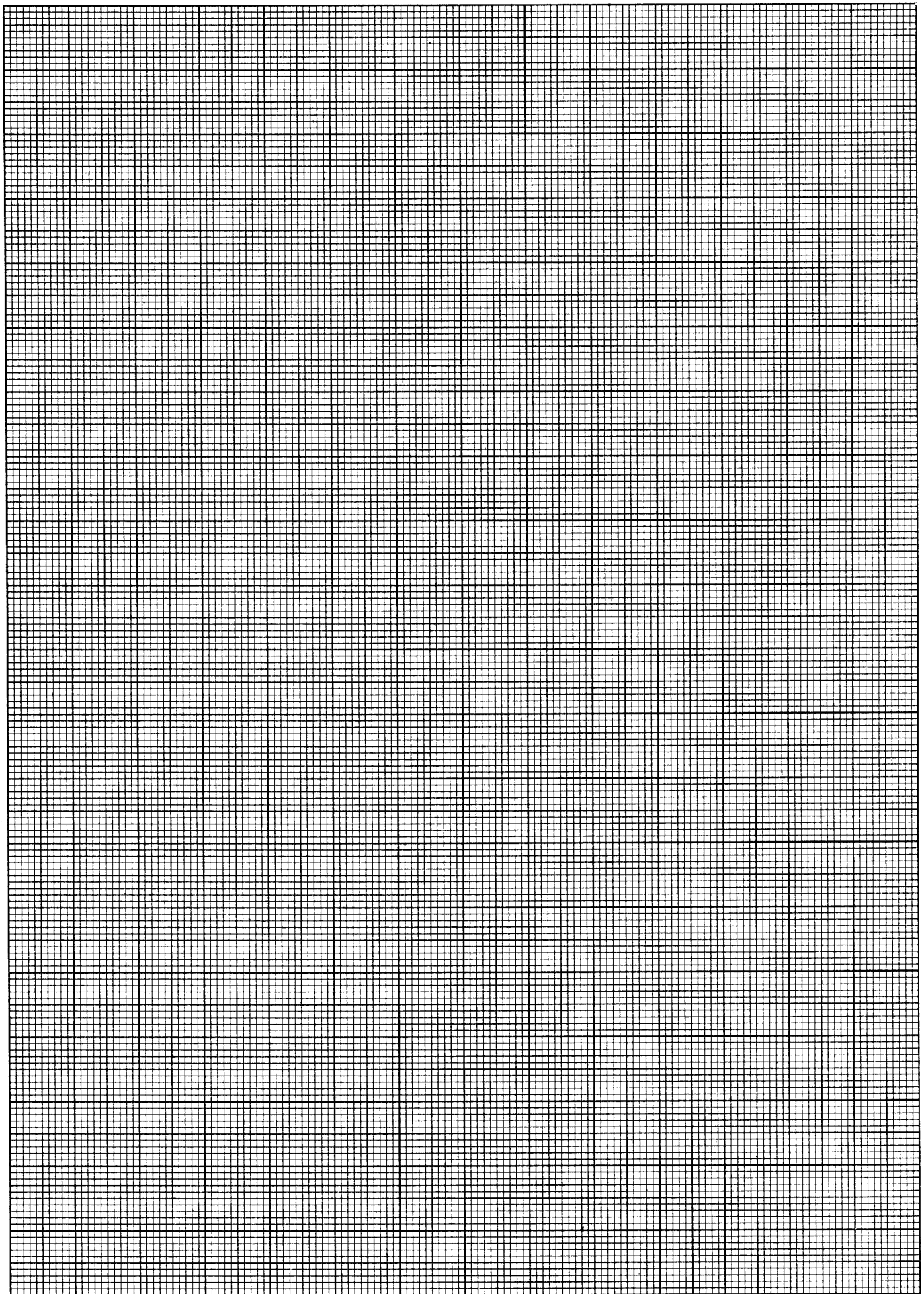


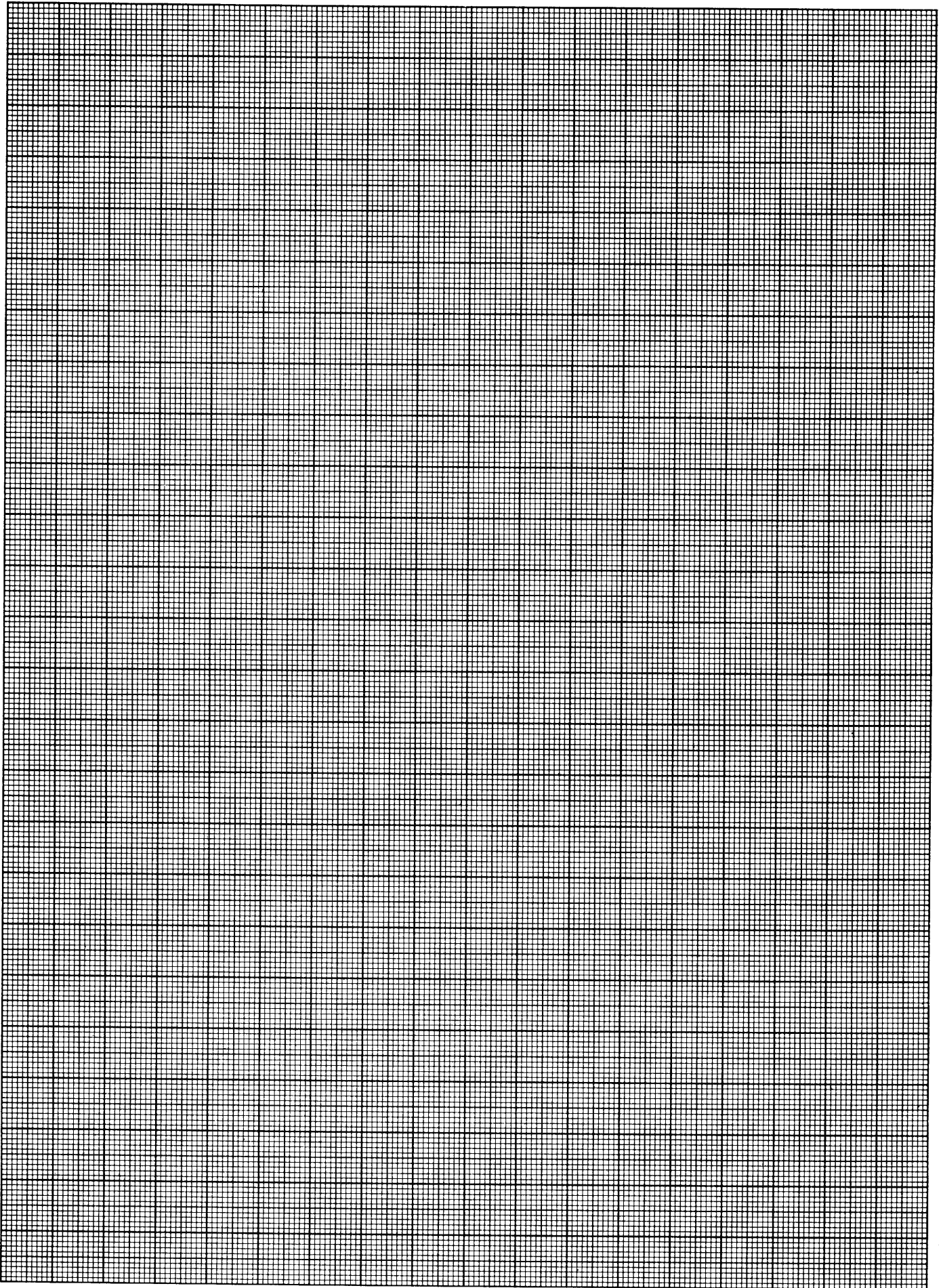


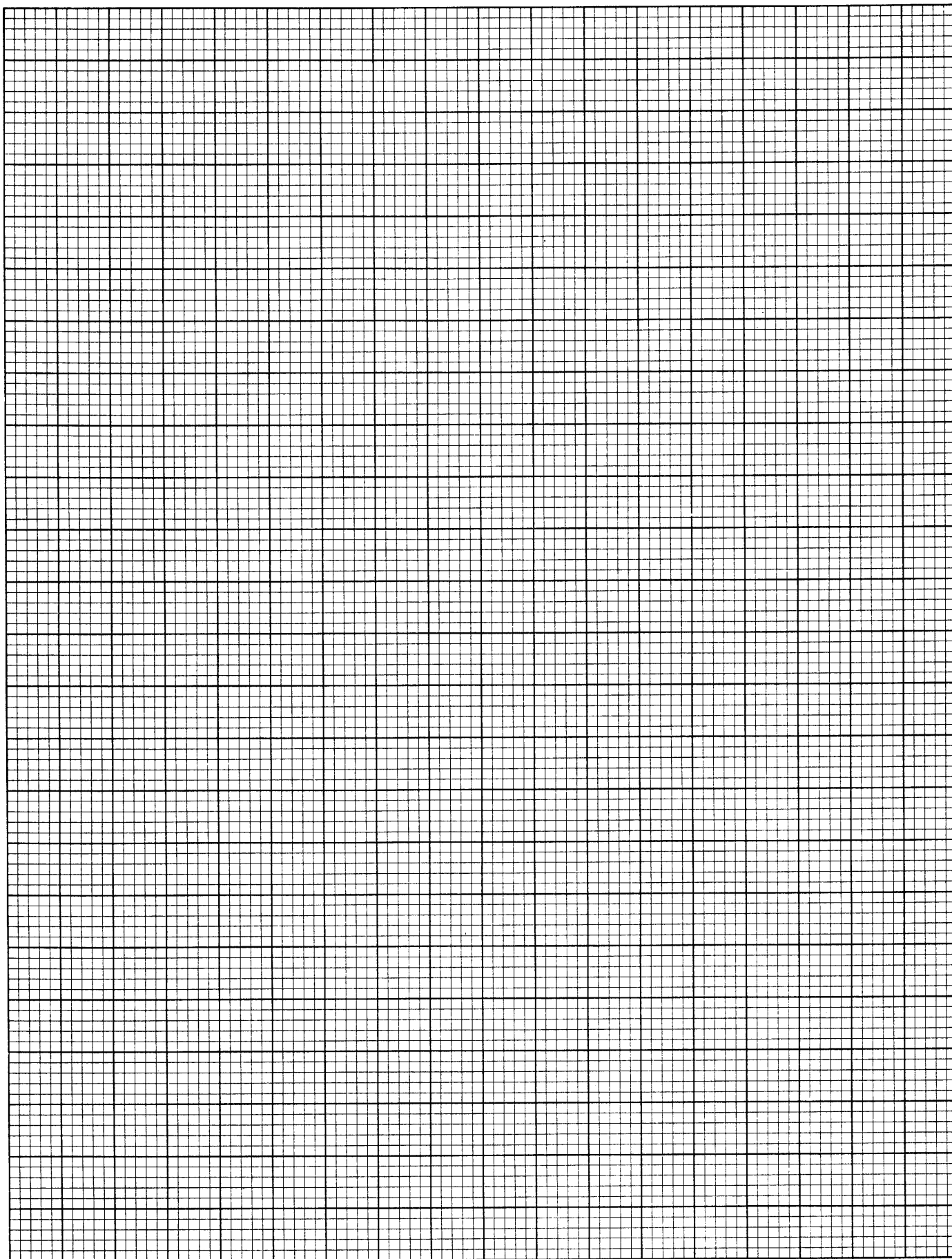


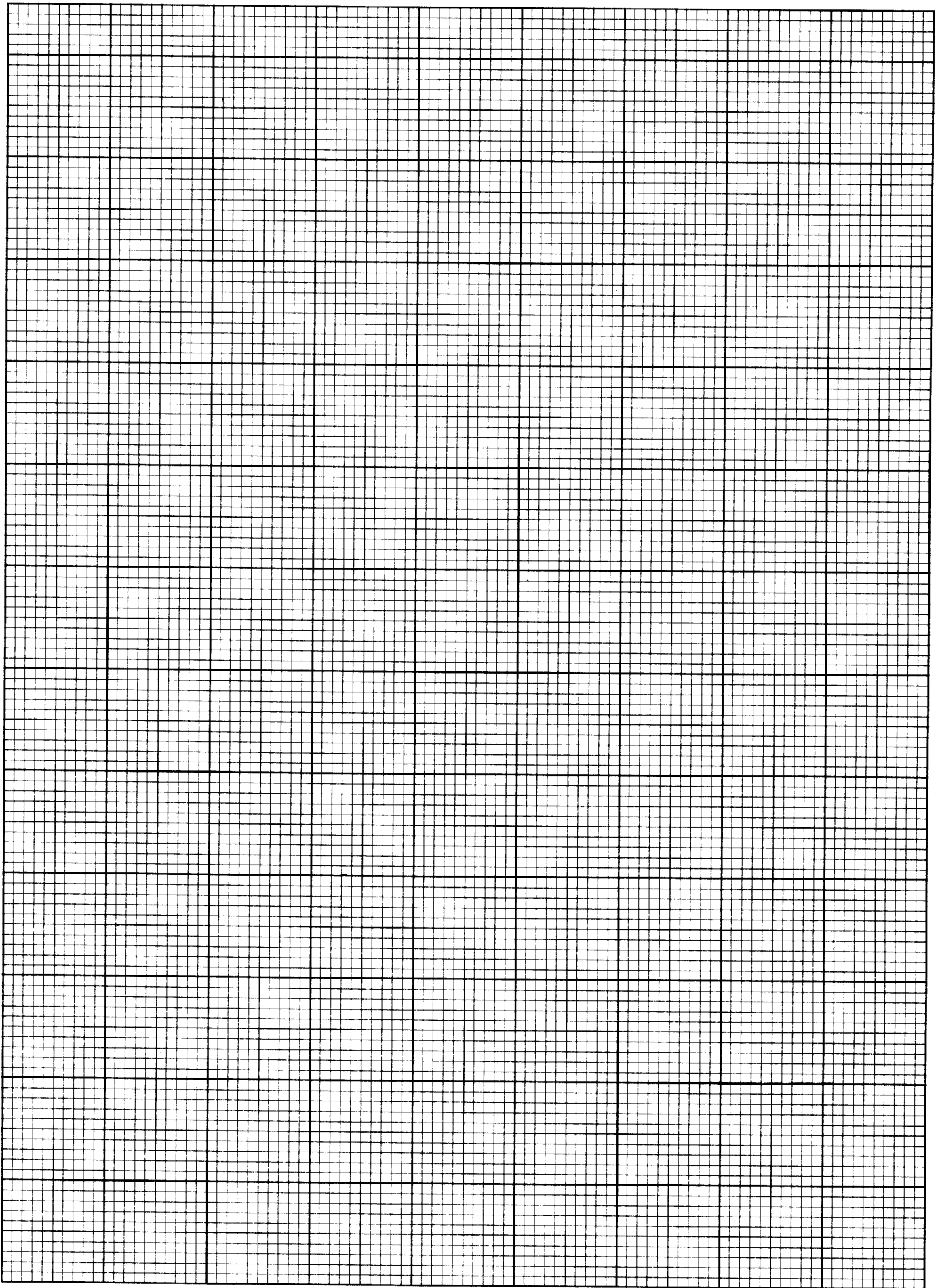


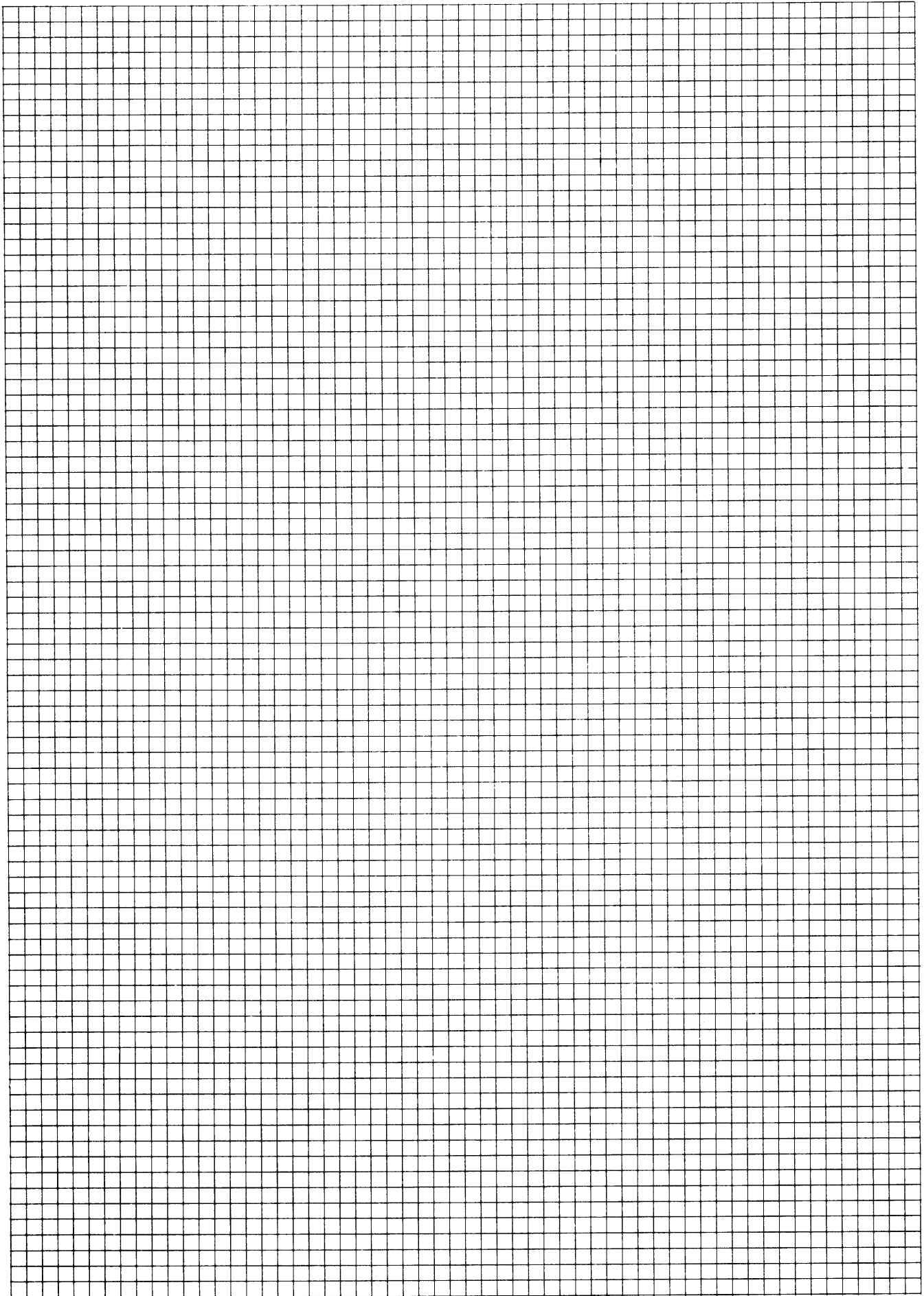


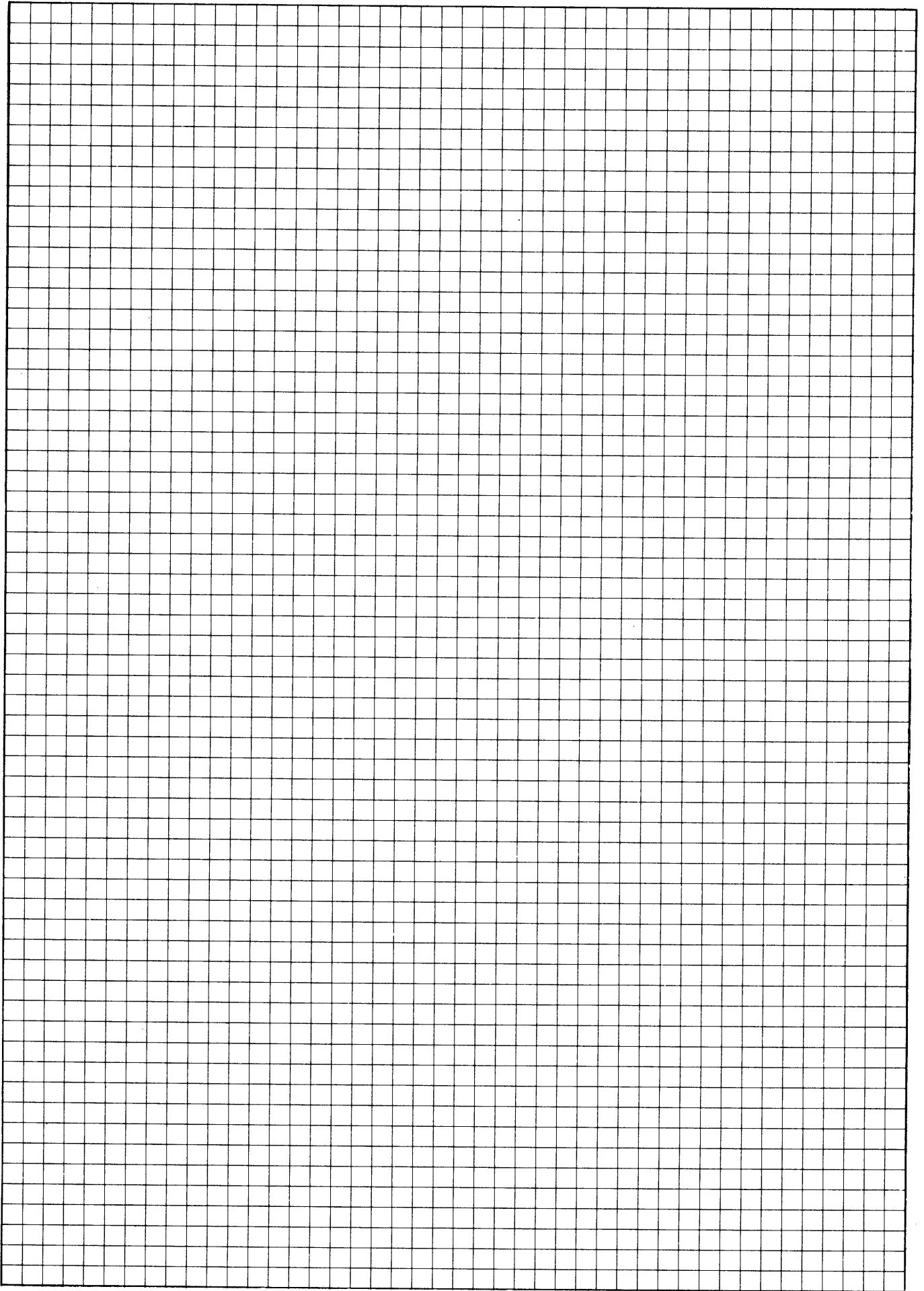


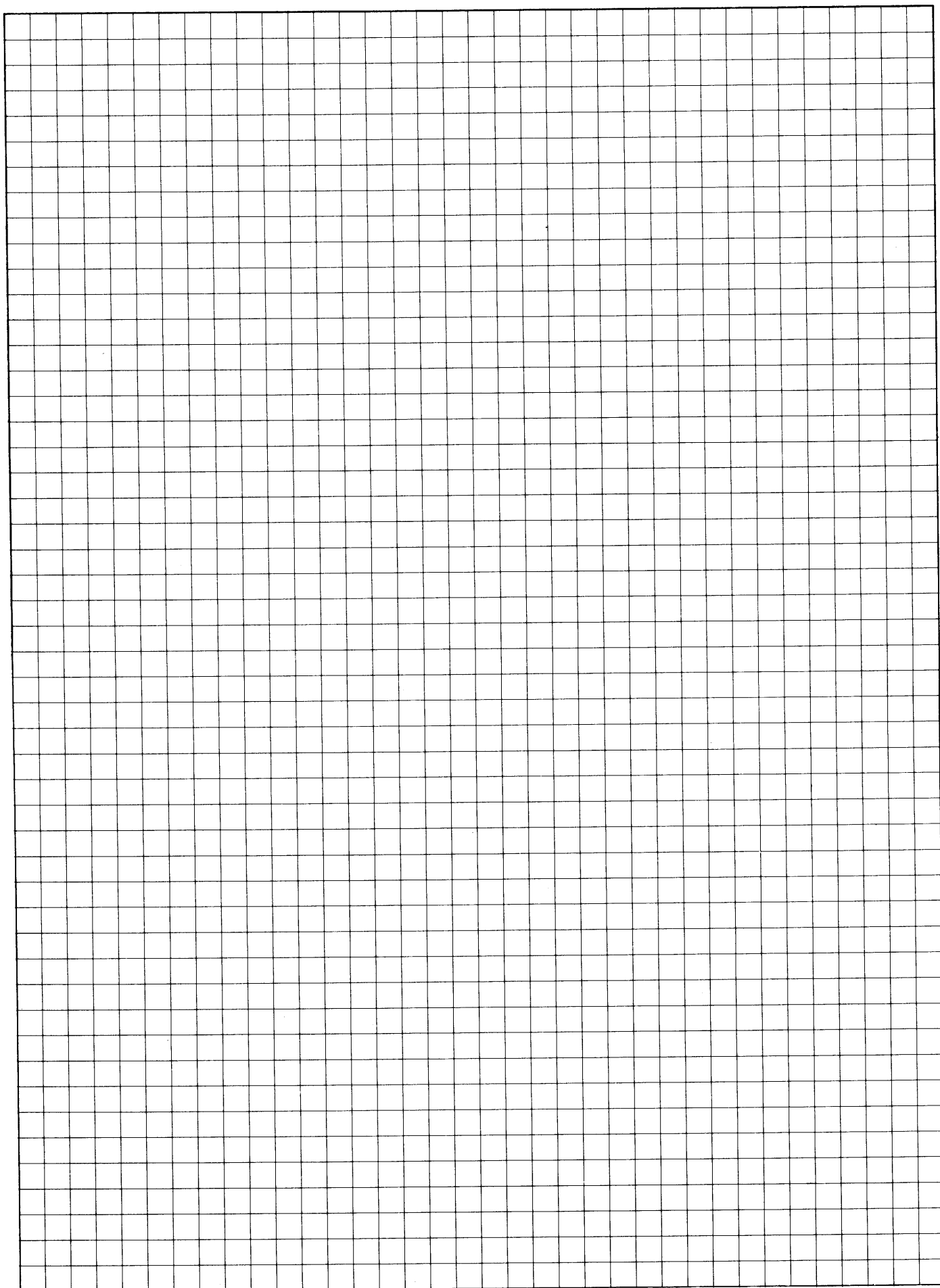


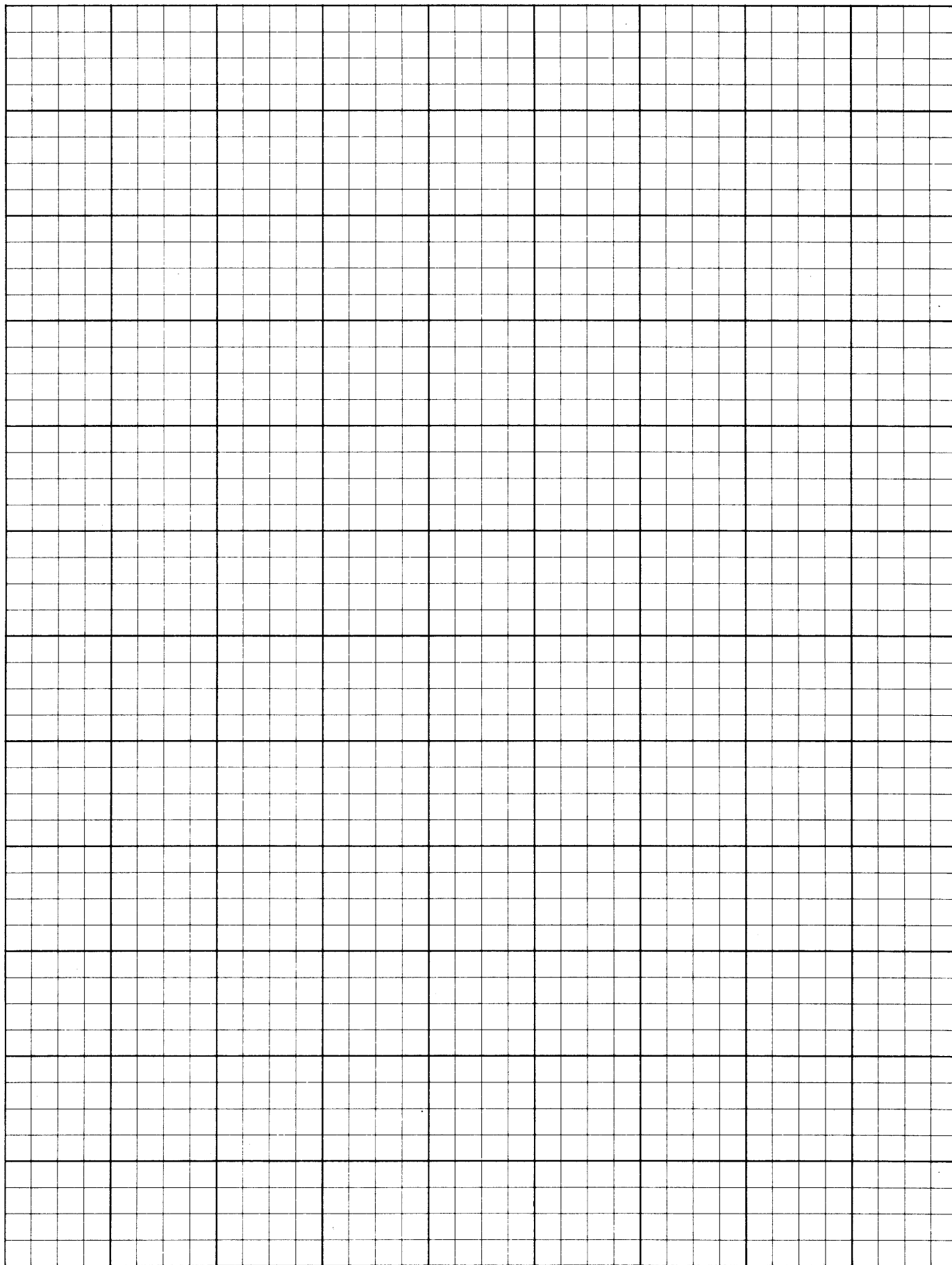


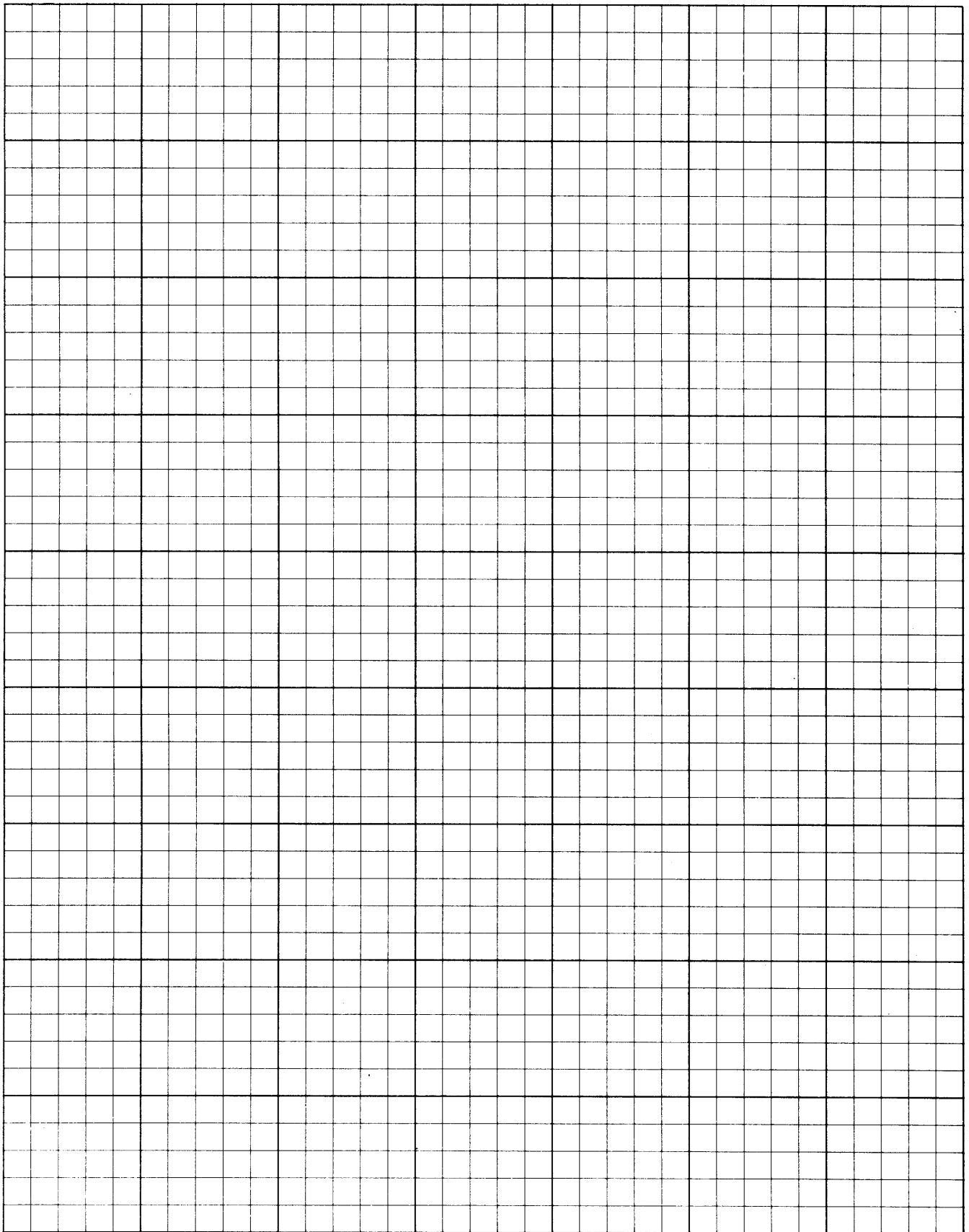


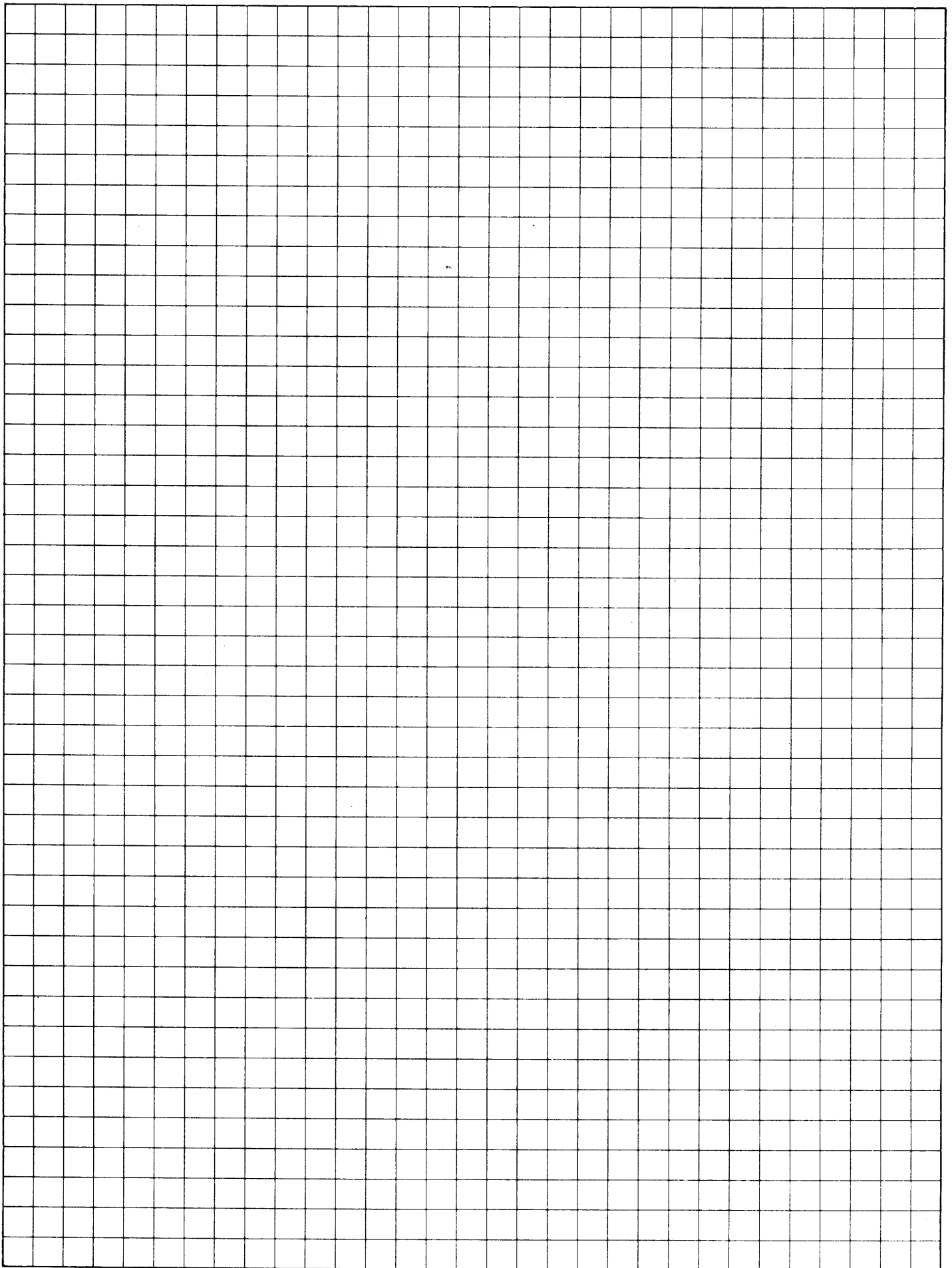


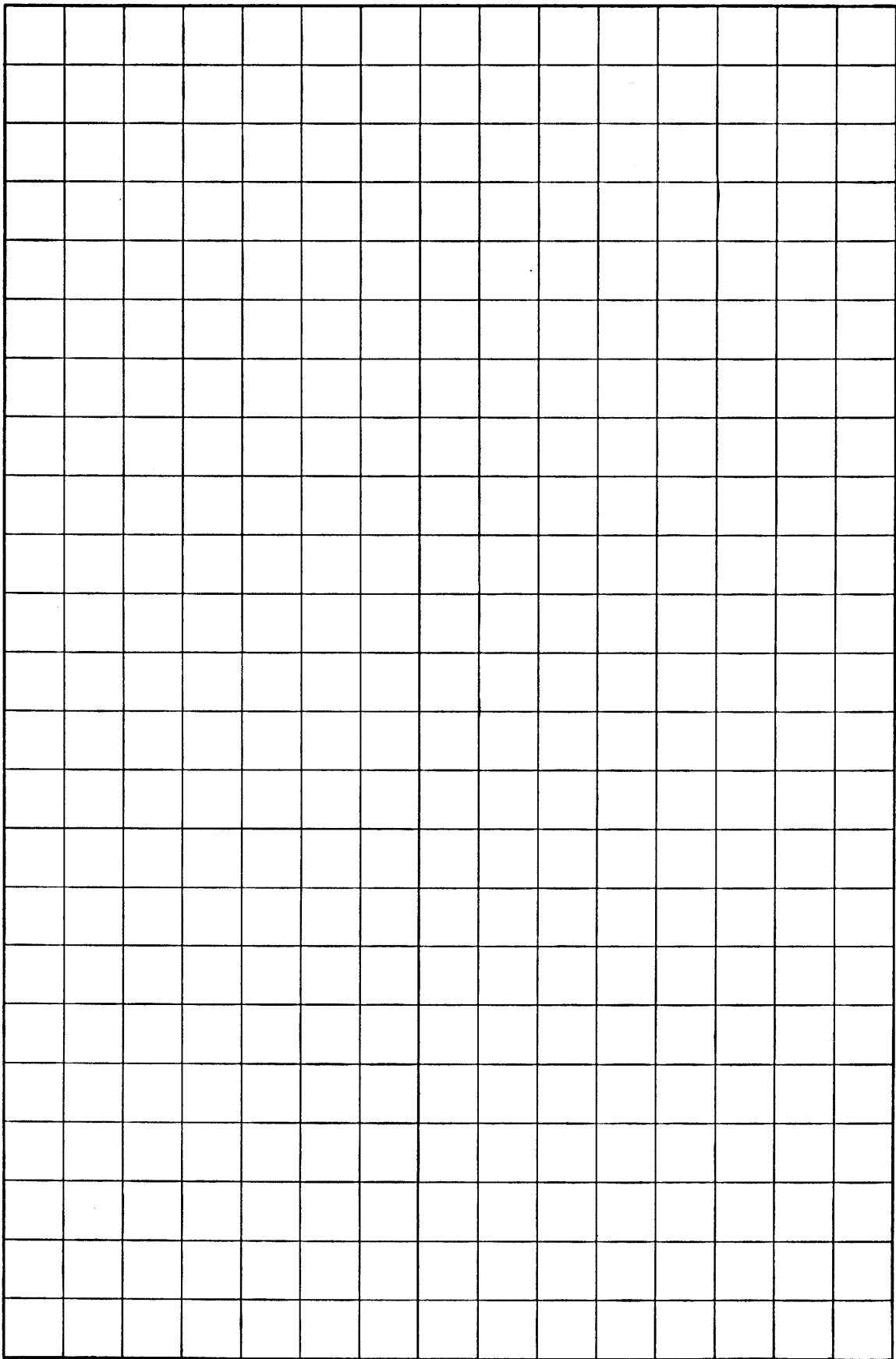




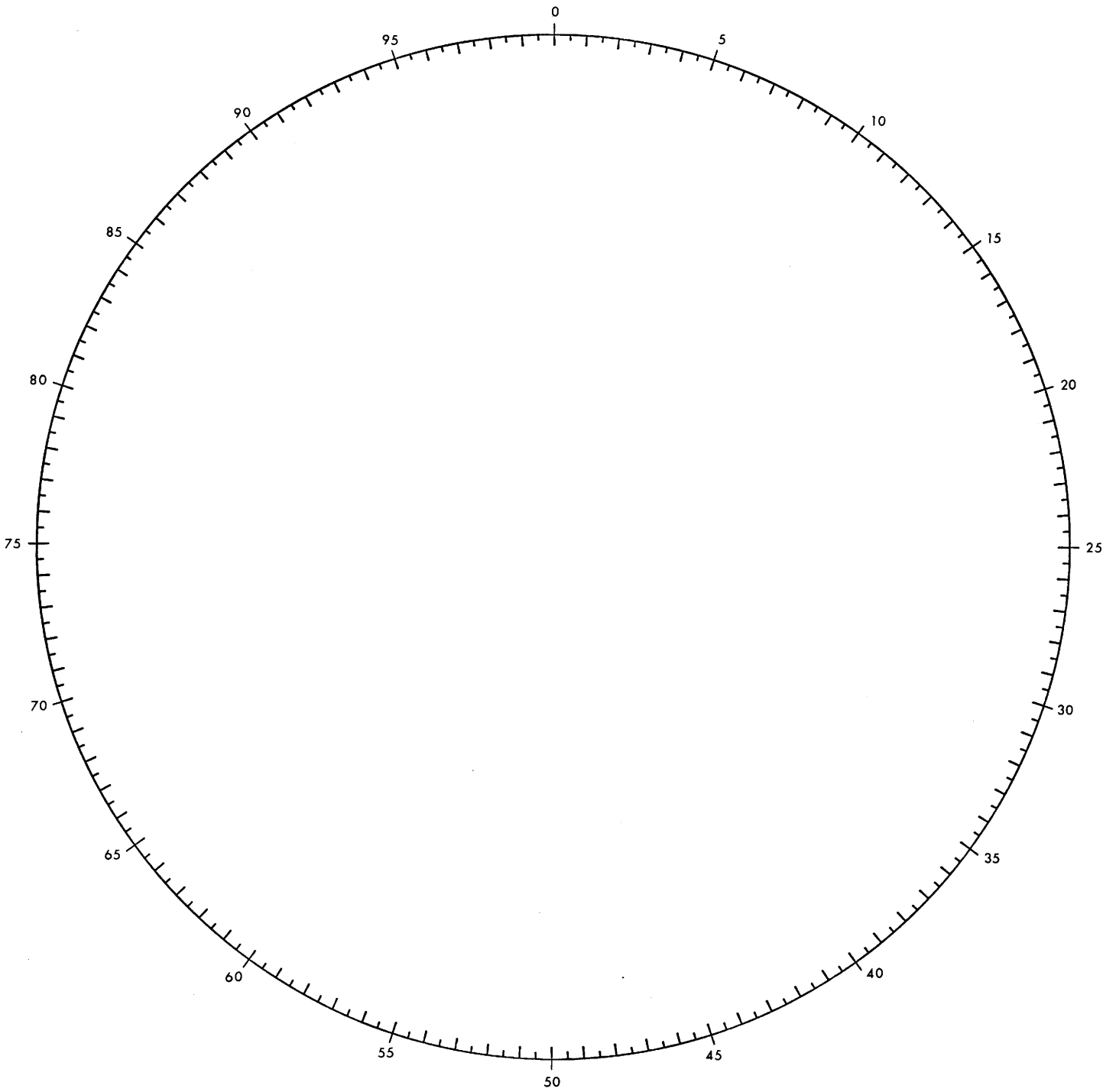




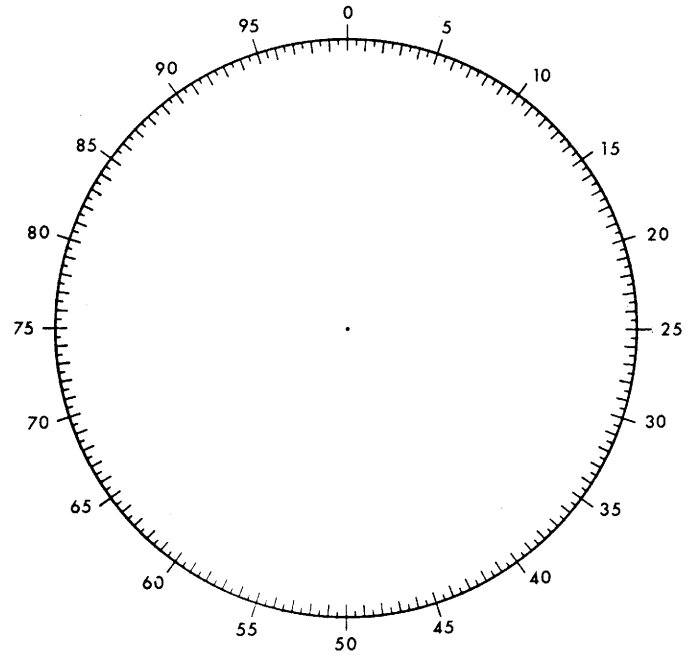
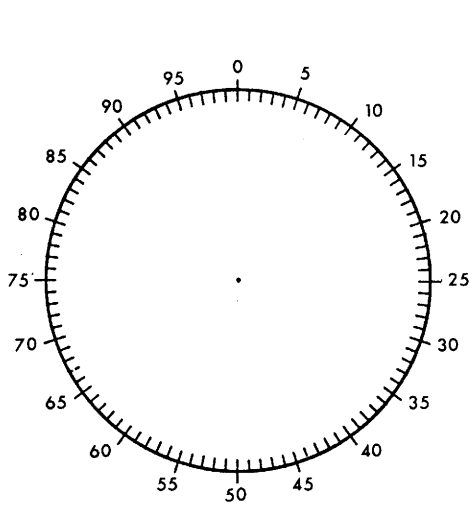
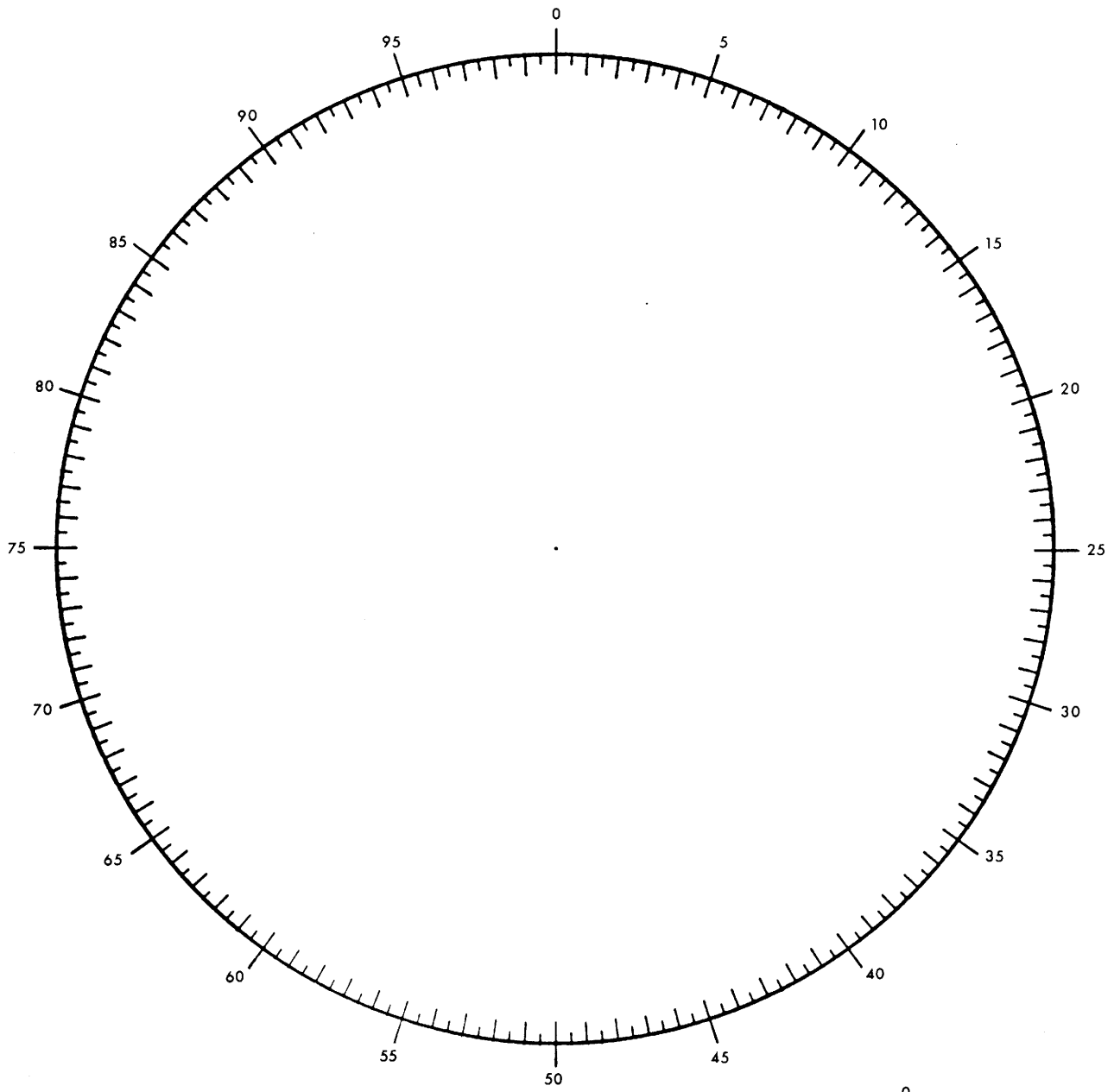




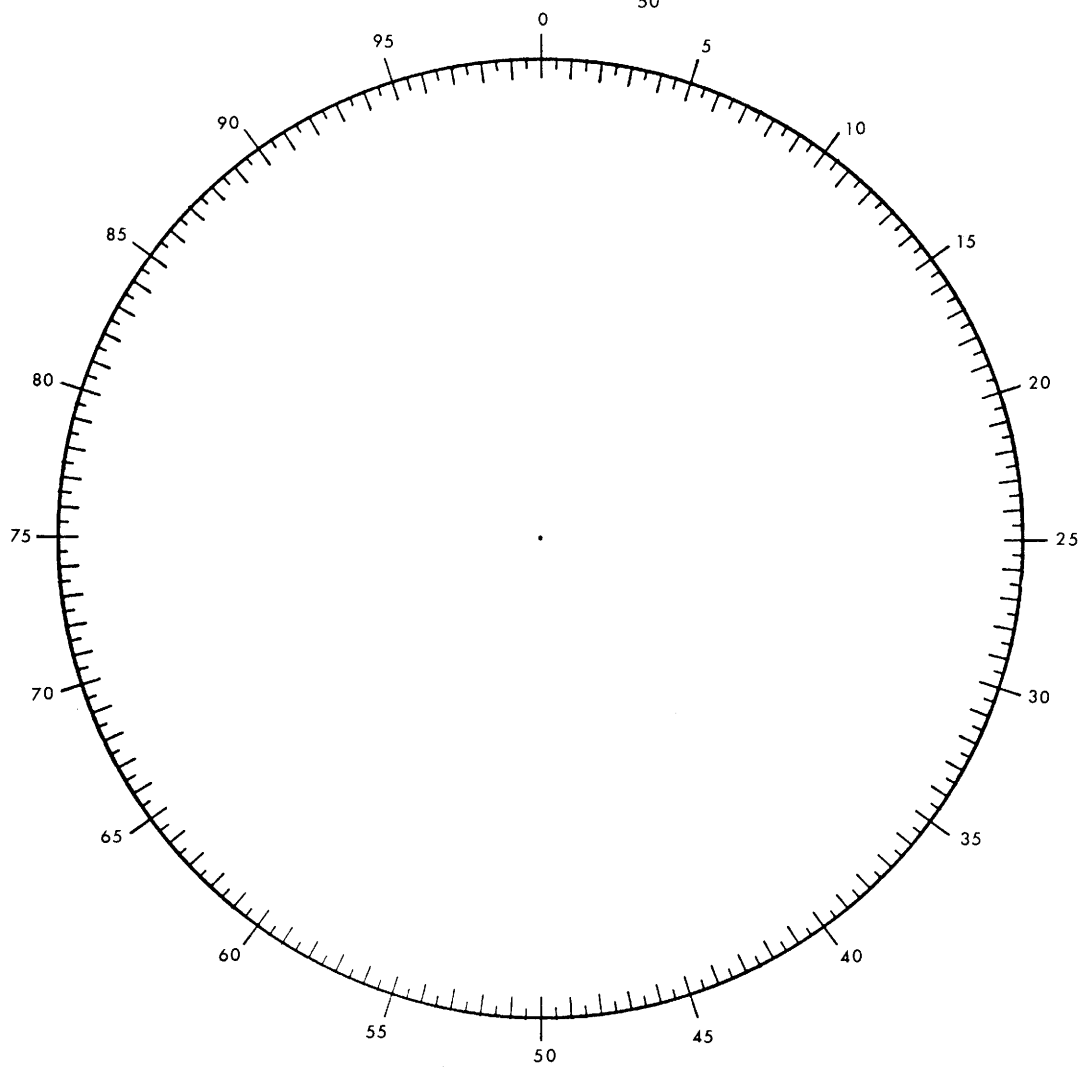
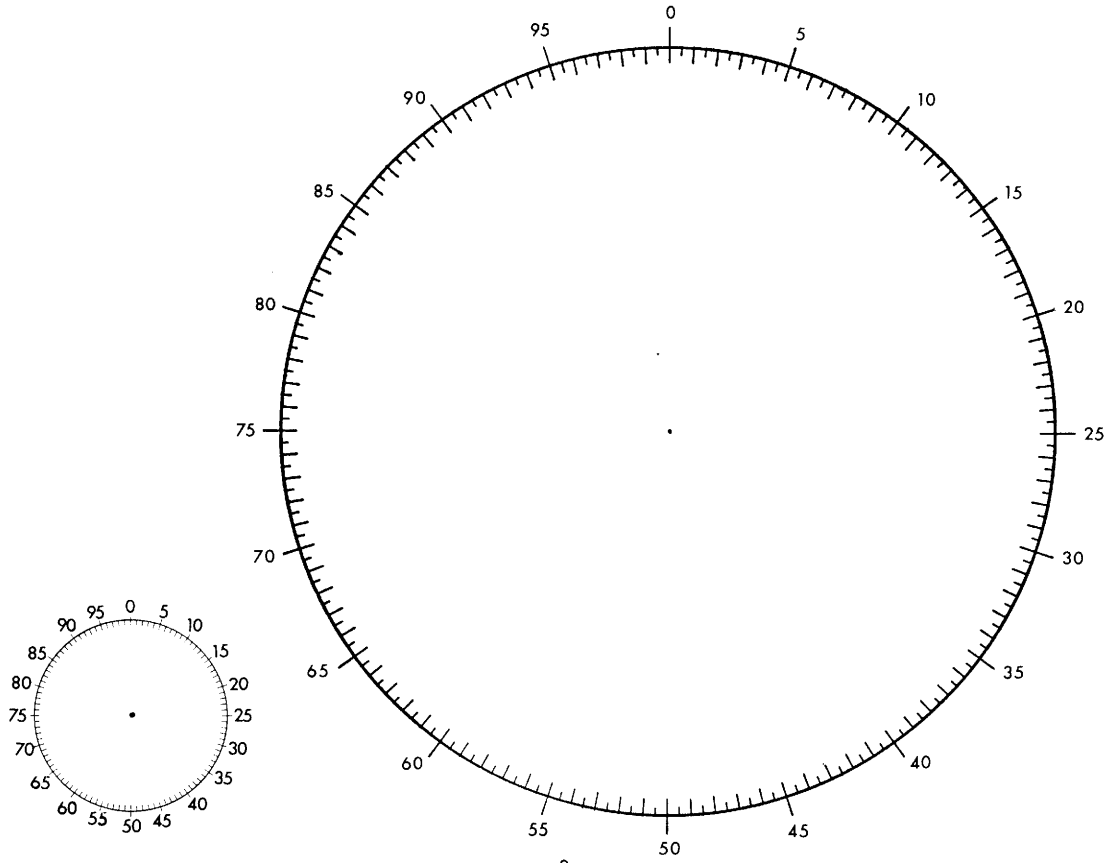
Circular Percentage 7-inch

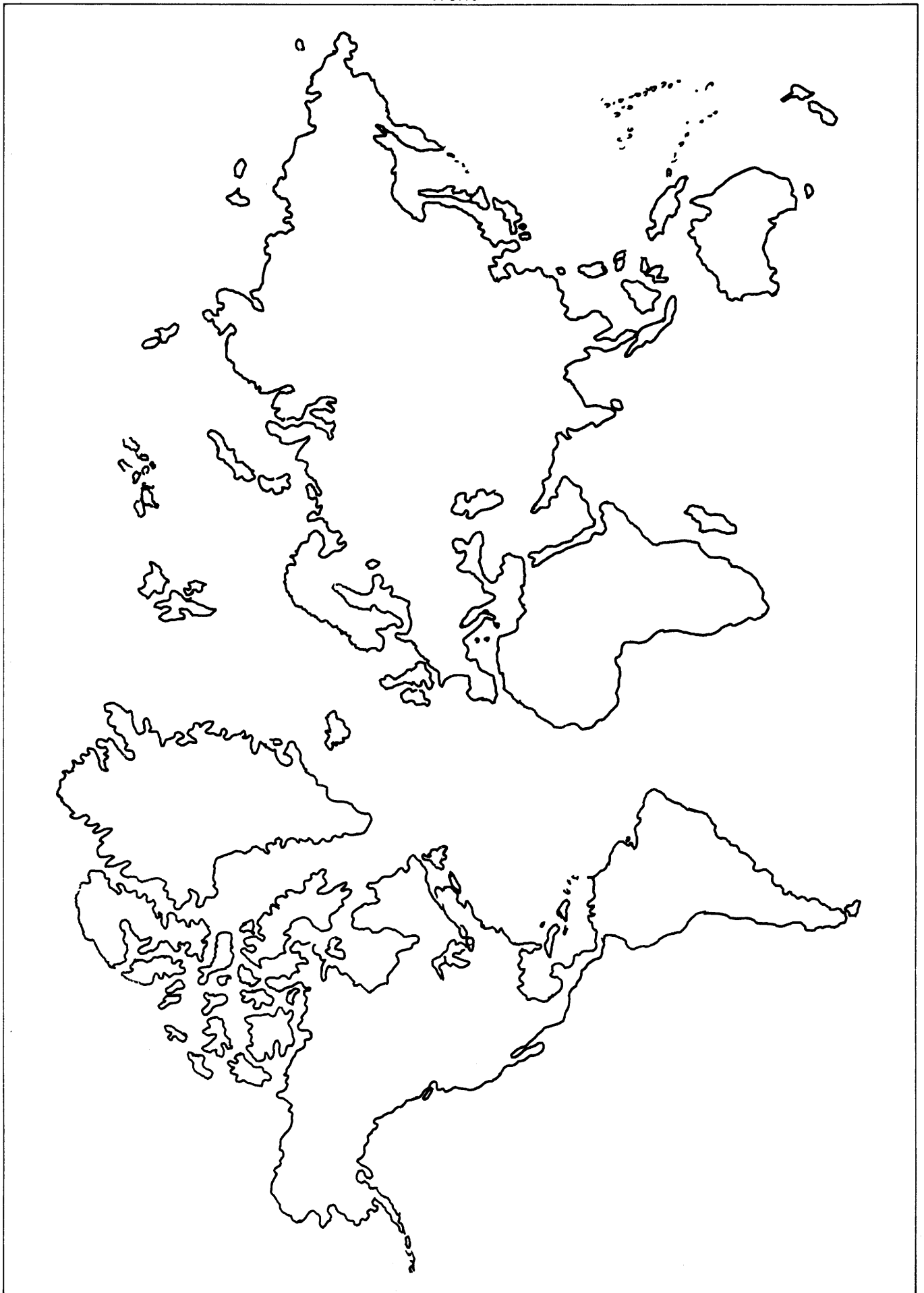


Circular Percentage 2-inch, 3-inch, 6-inch



Circular Percentage 1-inch, 4-inch, 5-inch

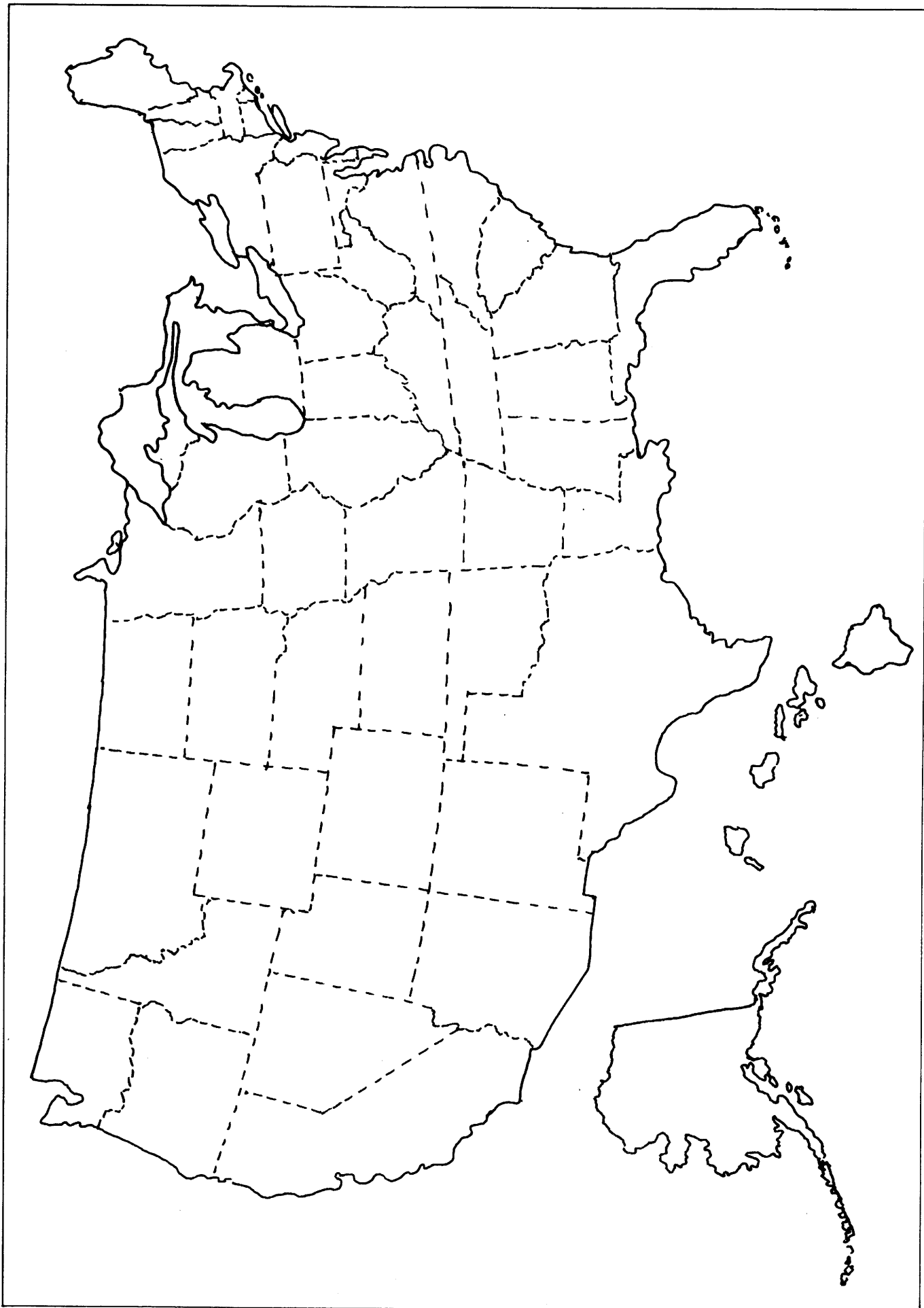


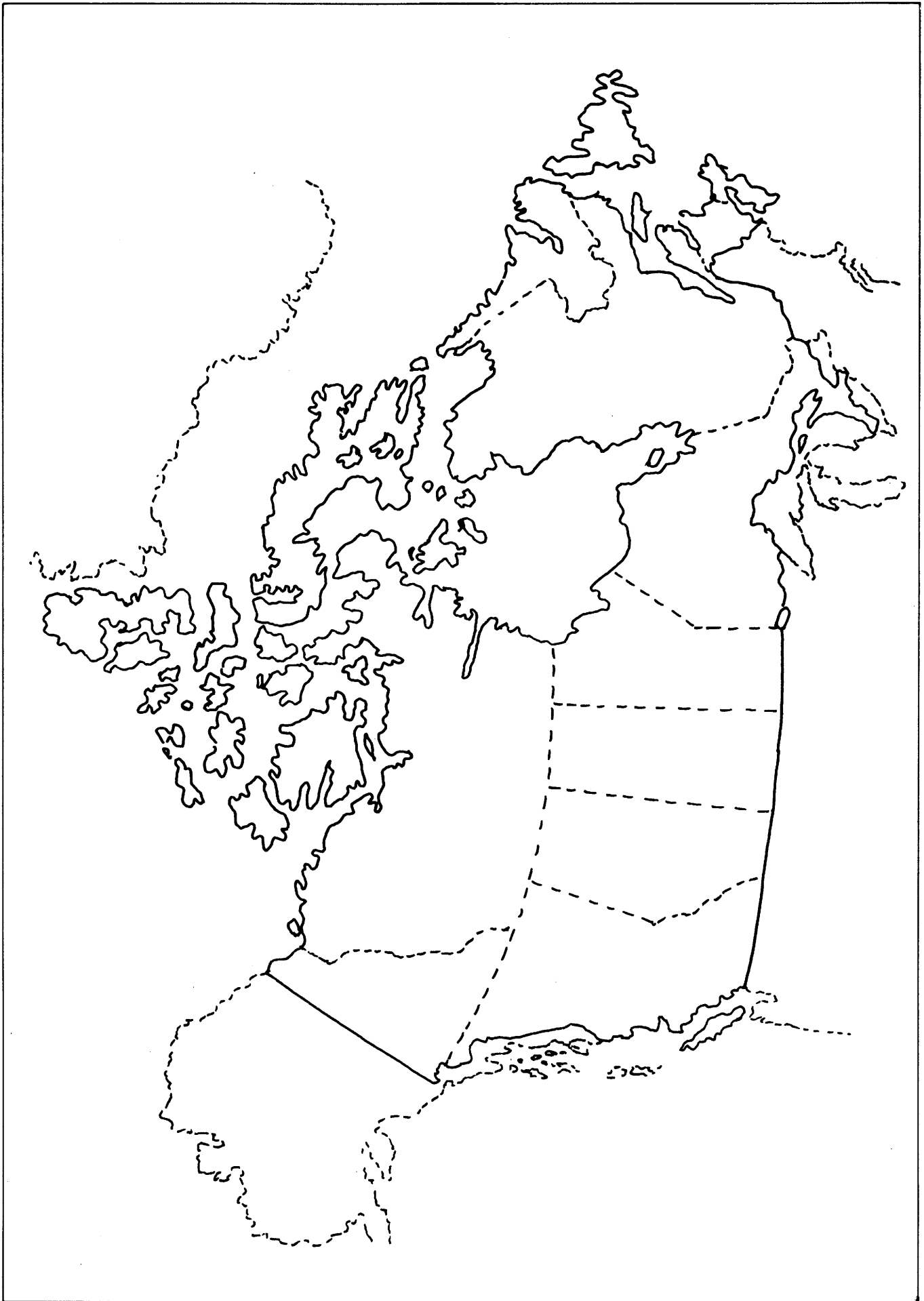


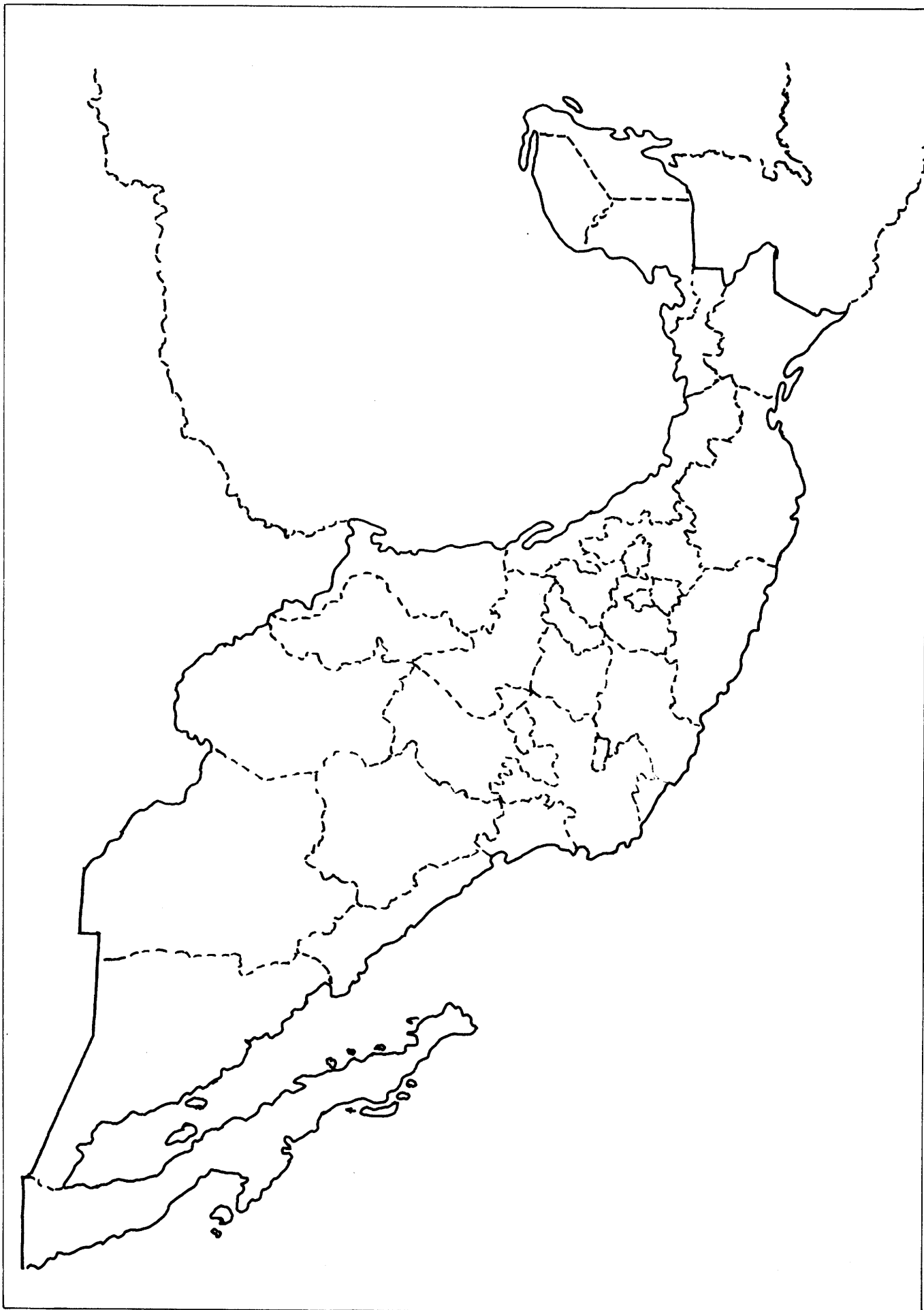
Western Hemisphere







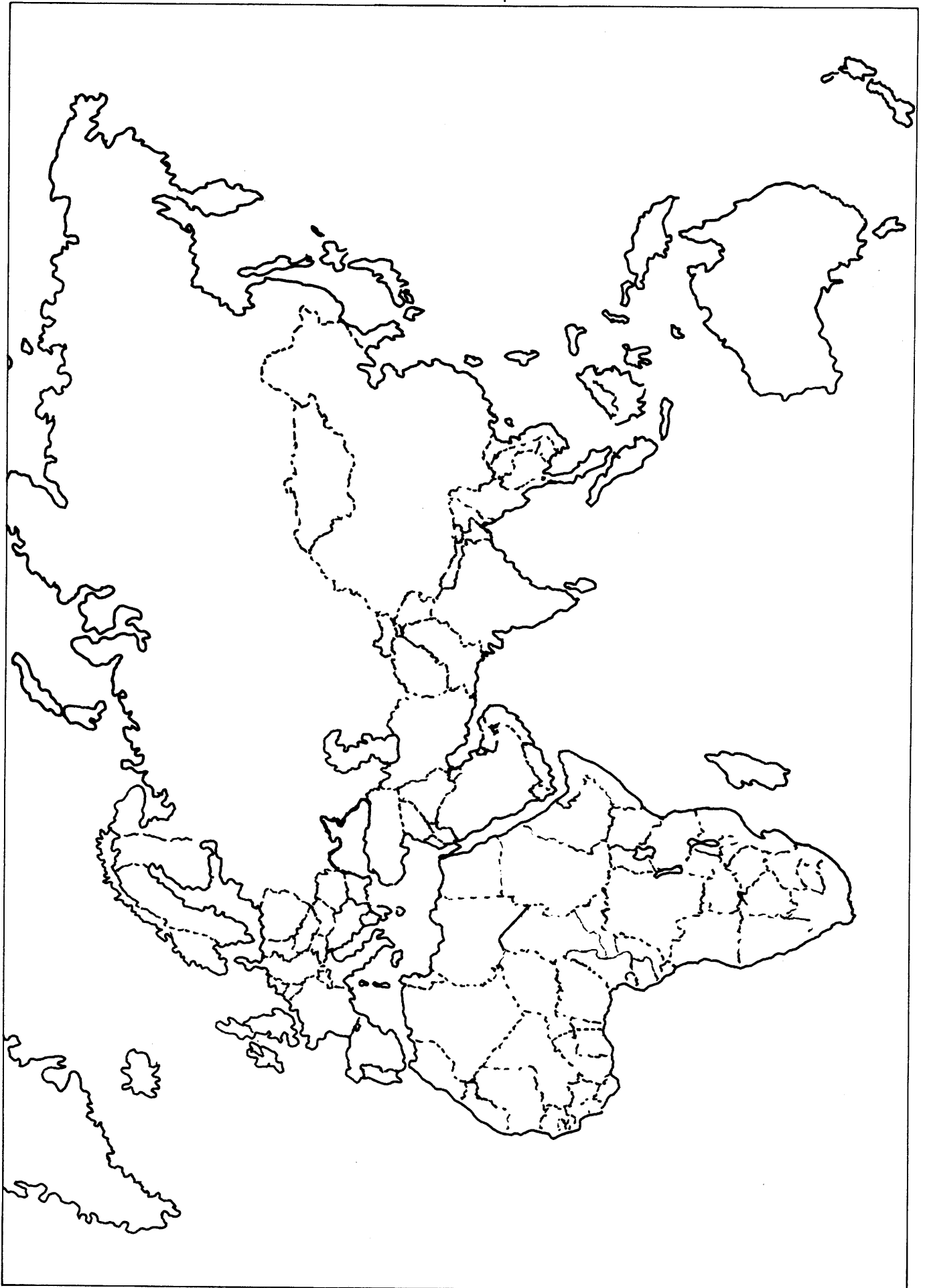


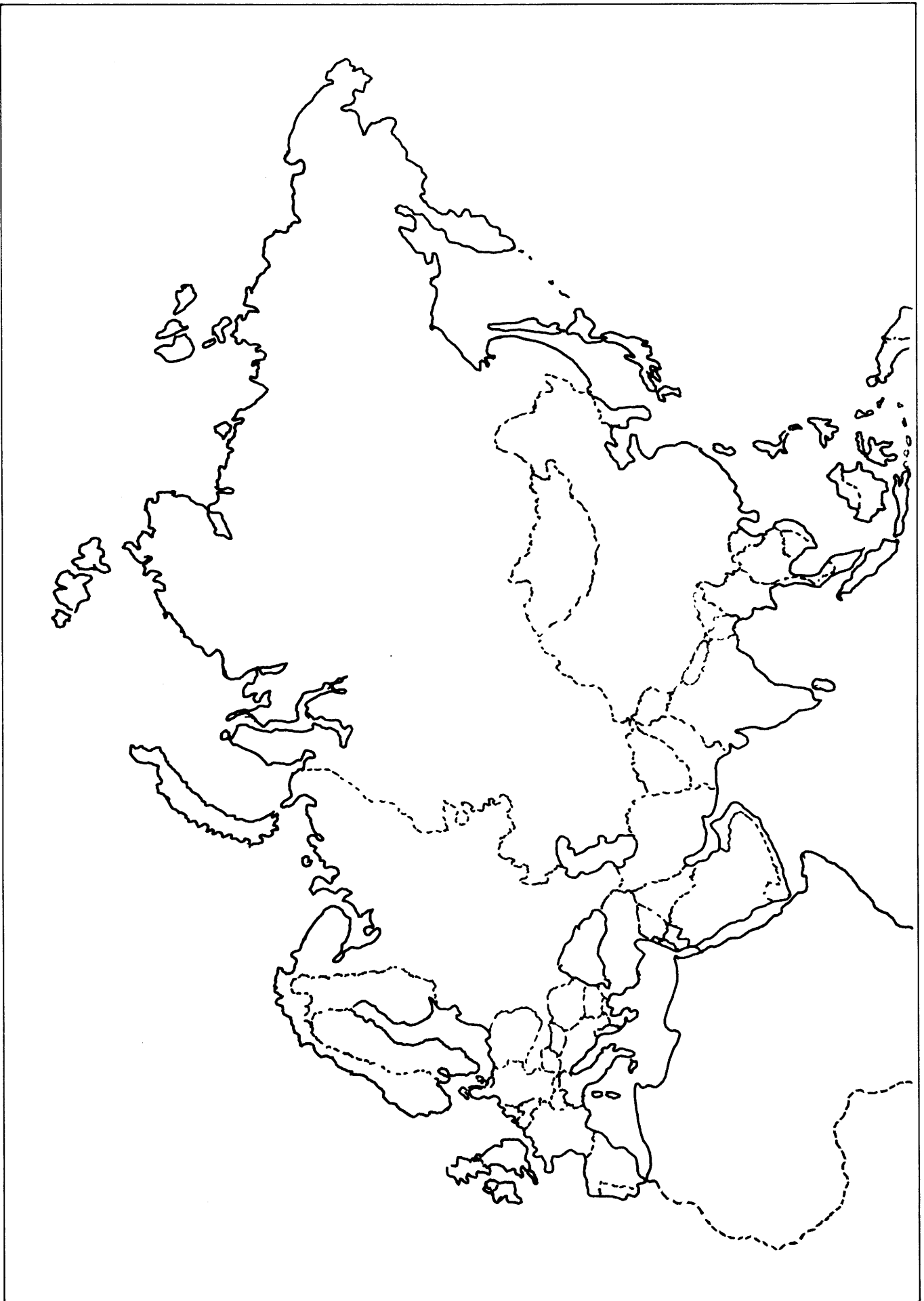


South America

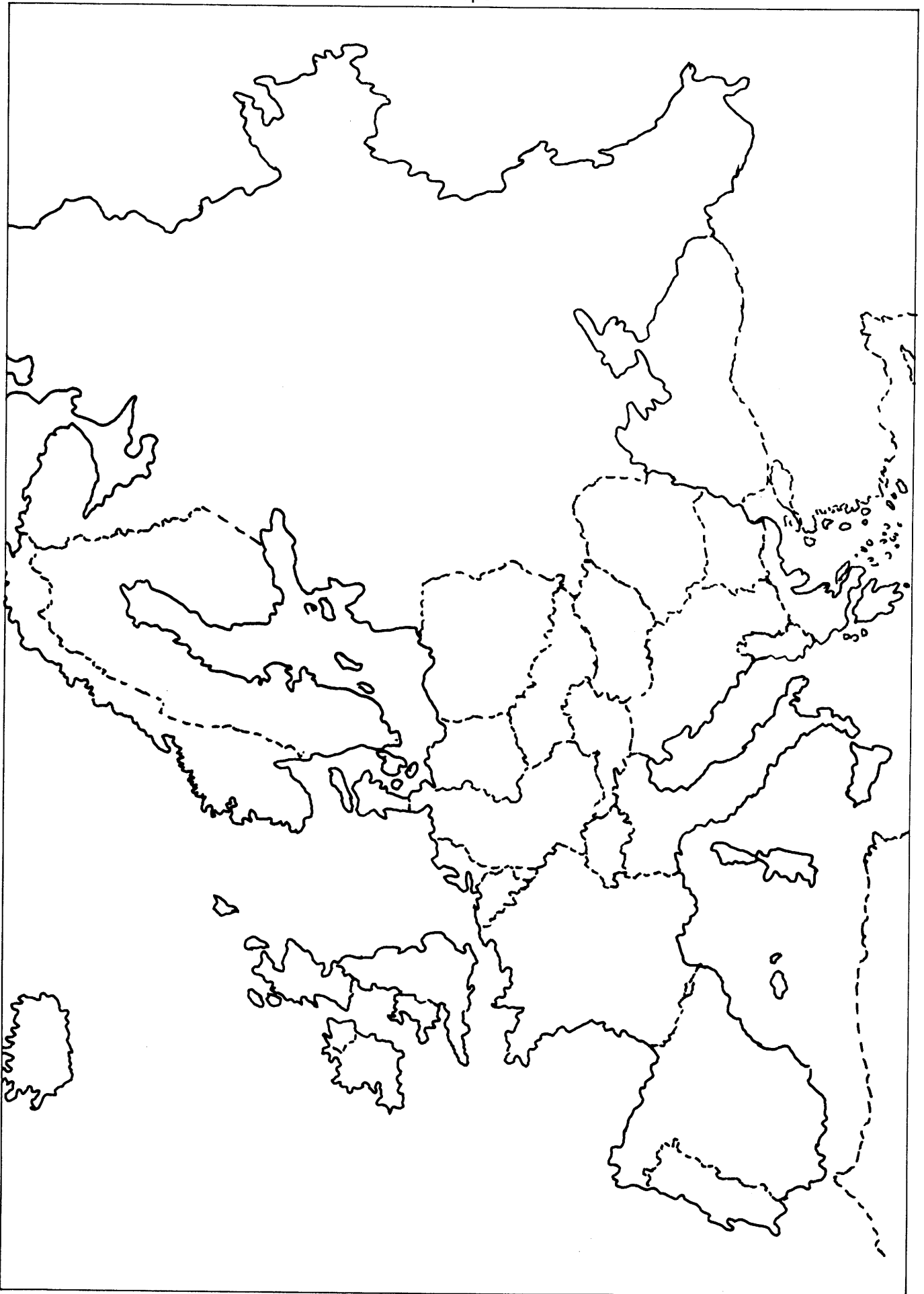


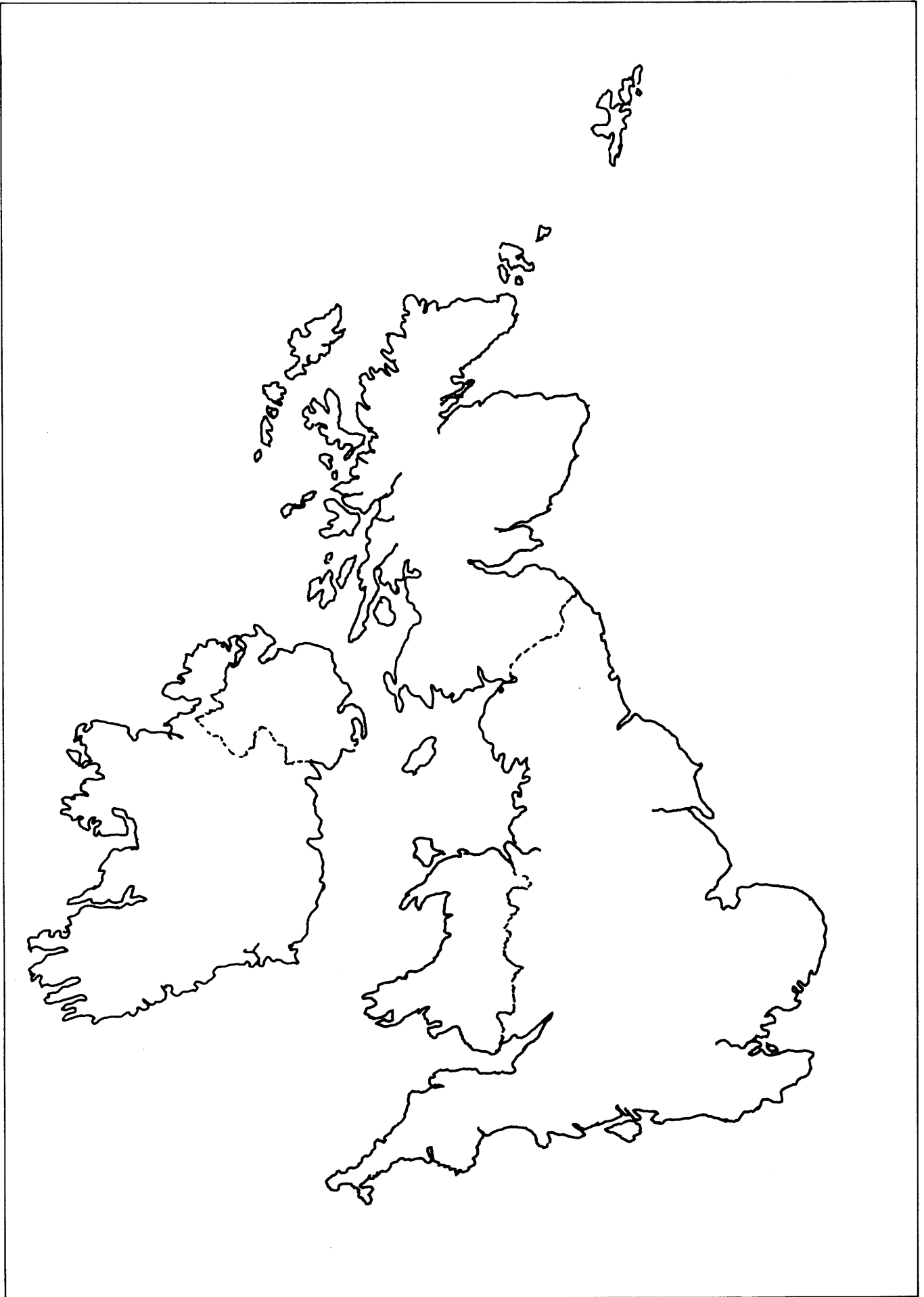
Eastern Hemisphere





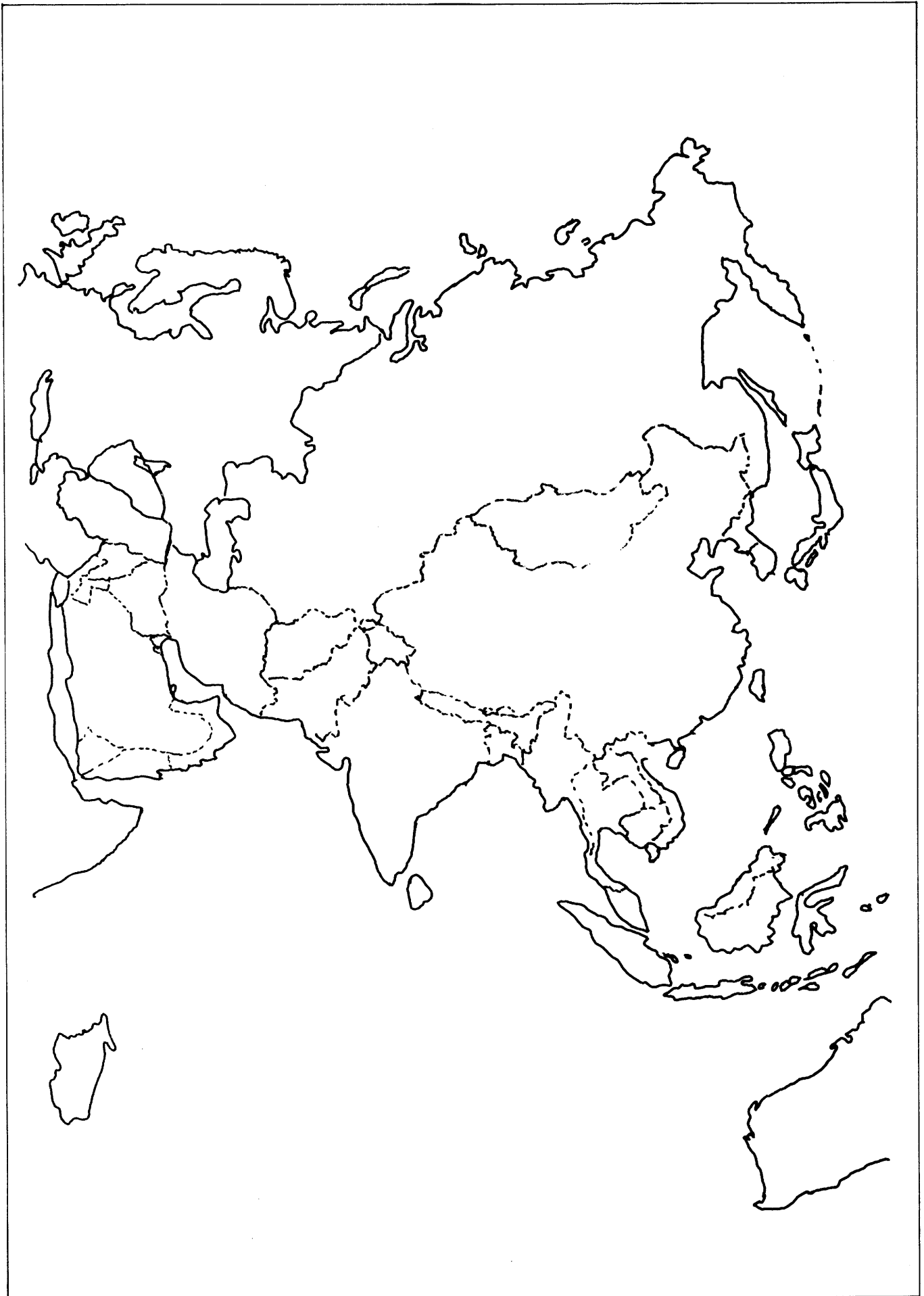
Europe



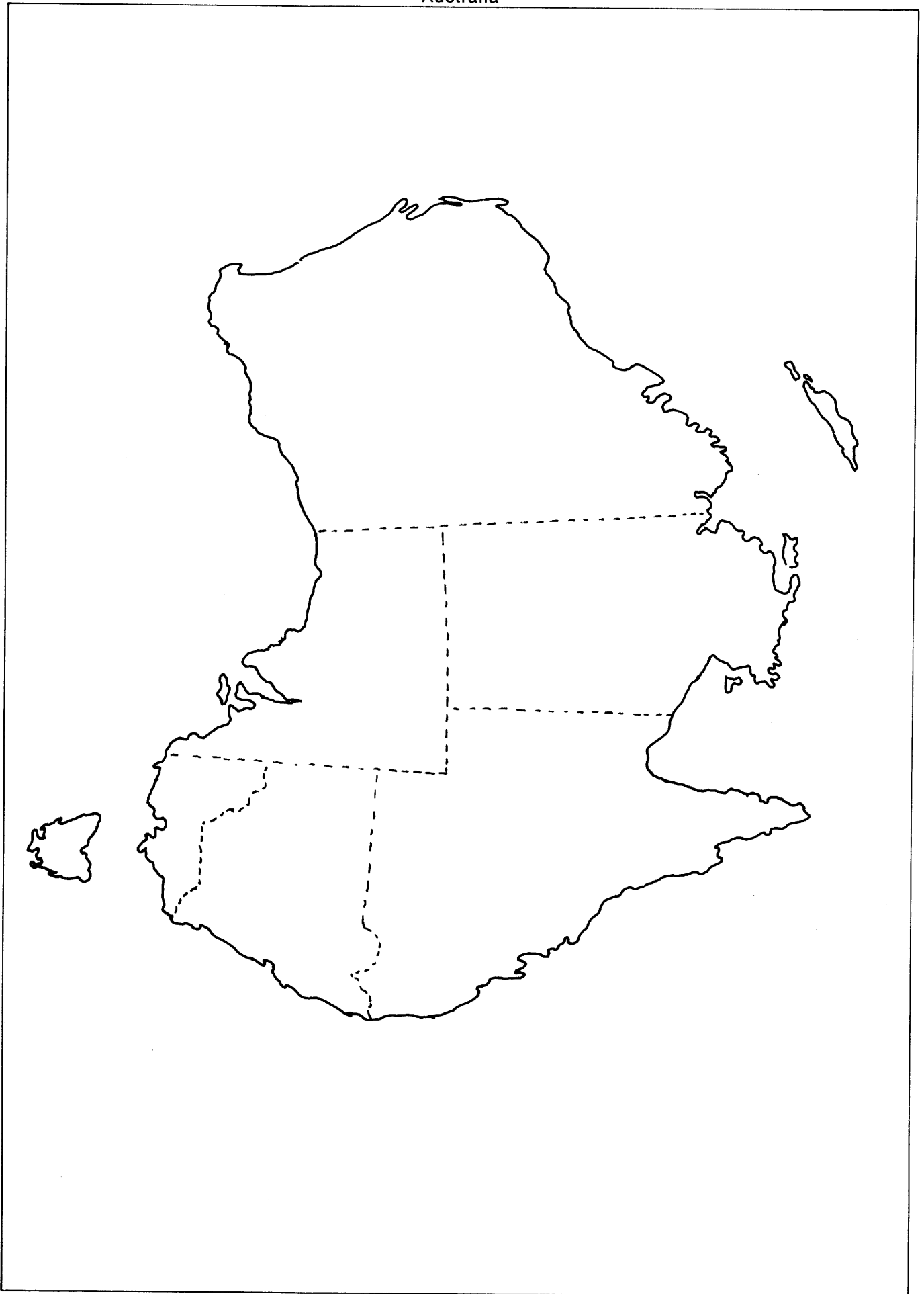


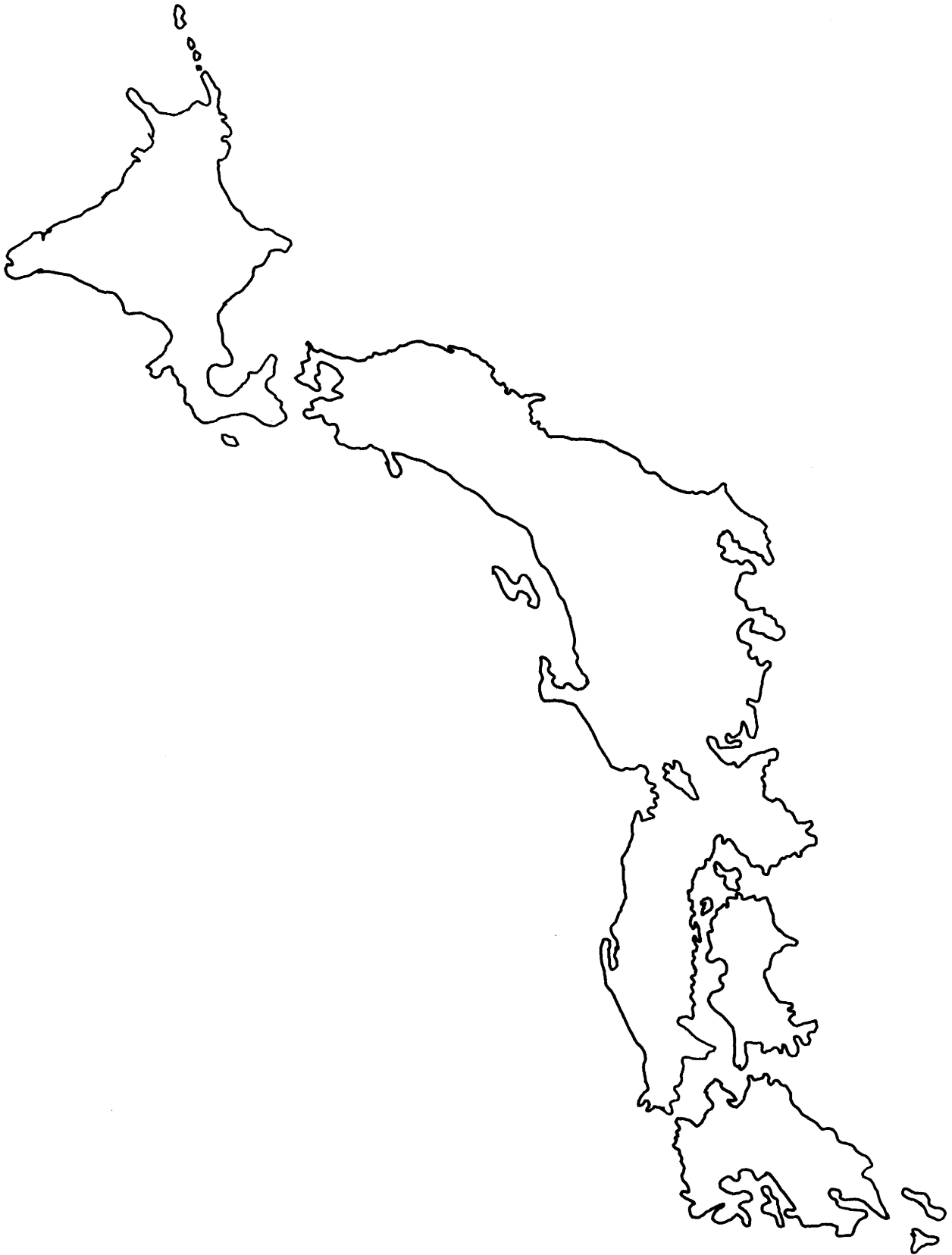
Africa

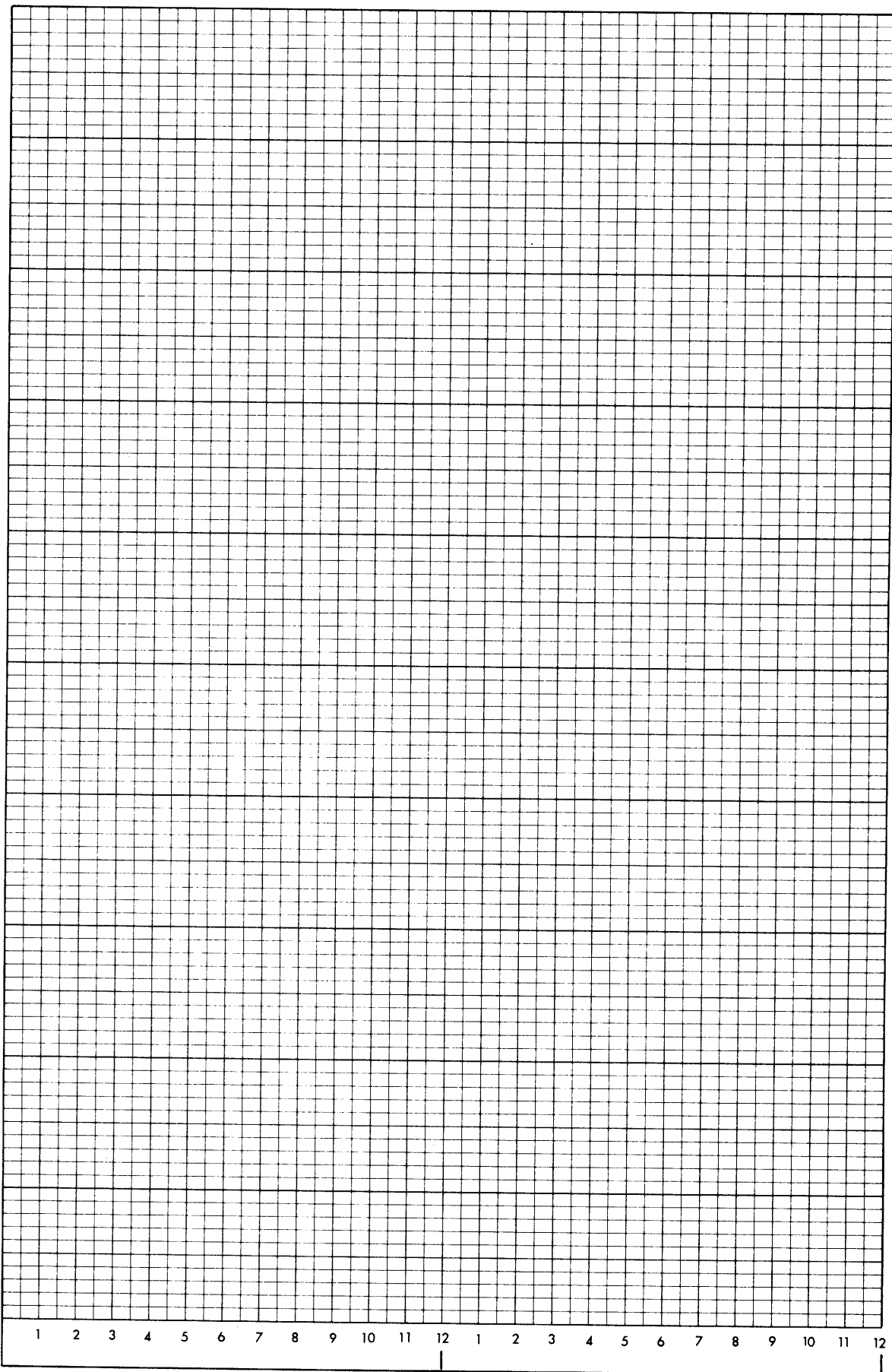




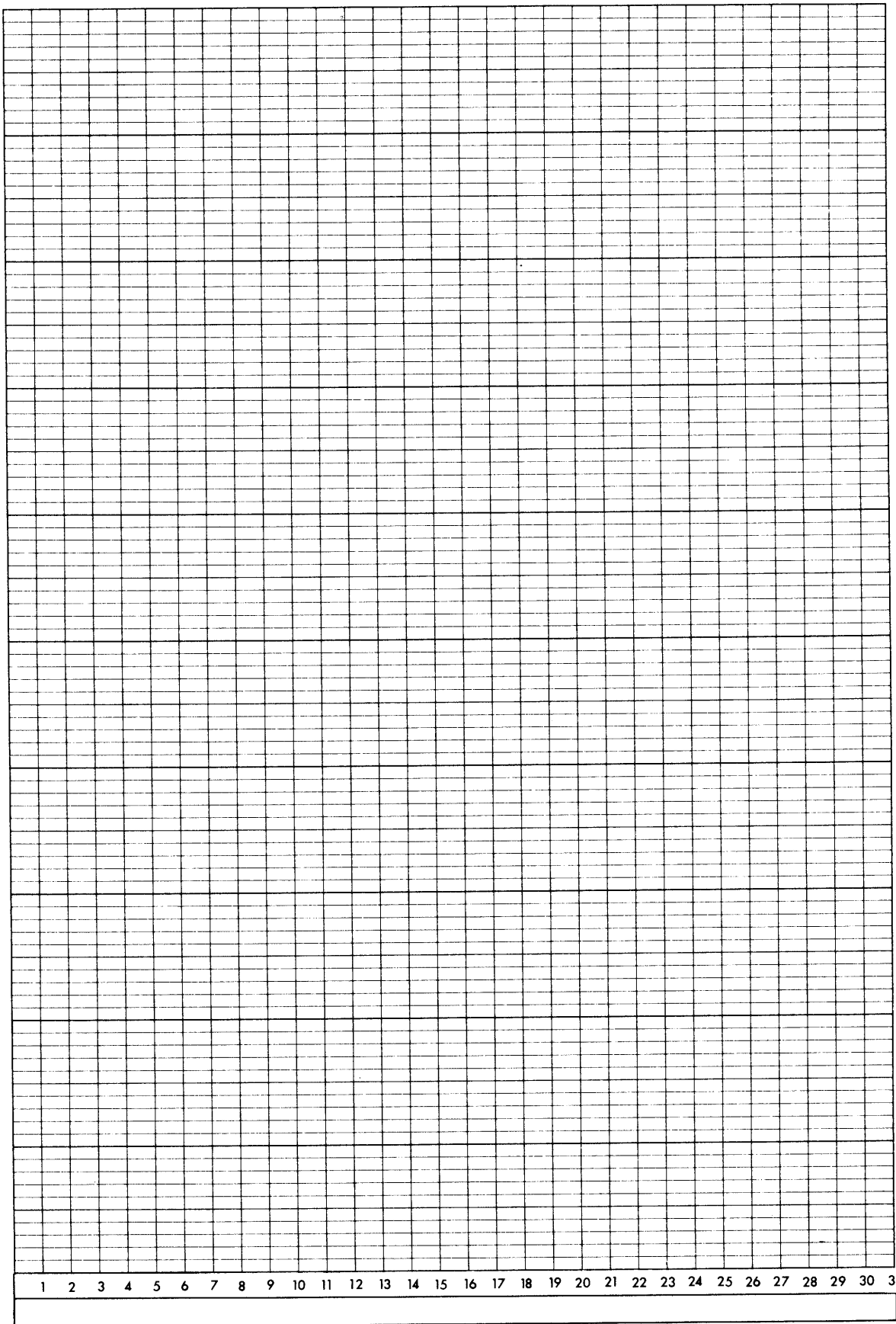
Australia

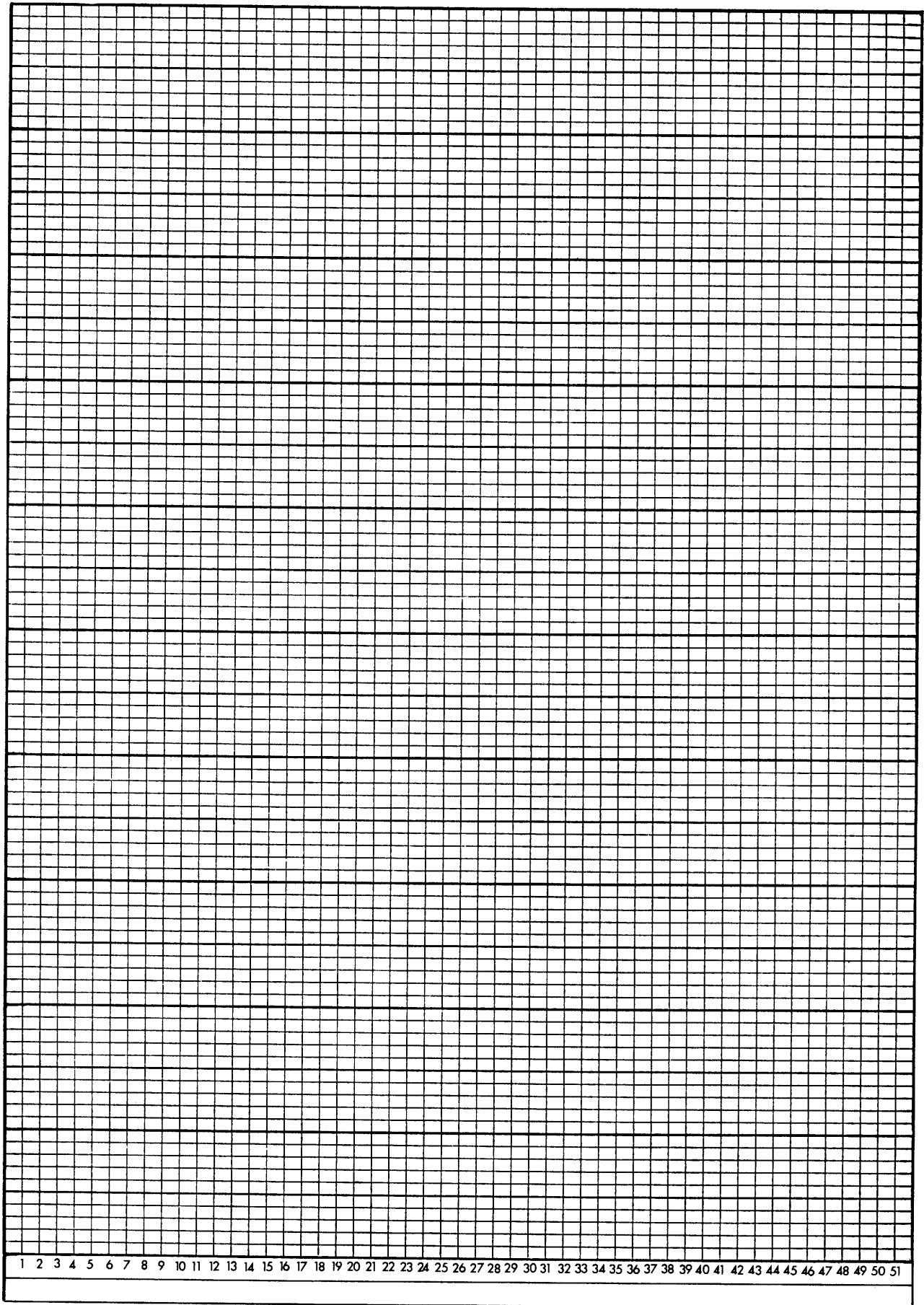






1 Month by Days 100 Divisions 5th, 10th Accent





1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51

