Cambridge
April, 1976

# IMPROVING CONVENTIONAL GRAPHICS FOR STATISTICAL DATA

Edward R. Tufte
Woodrow Wilson School
Princeton University

**ROCKY LOVES CHARTS, but do they ever lie to him?**

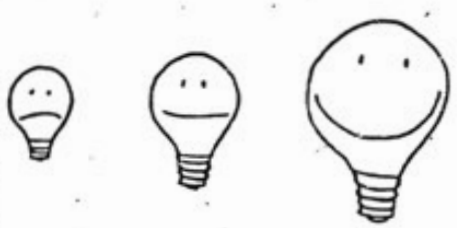
"The government has never pulled together and boiled down the total spectrum of information," says the Vice President. So he orders the Census Bureau and Budget Office to furnish him a weekly notebook full of charts on economic activity like auto sales, steel production, interest rates. He sees to it that Ford gets a copy, too.

"I'm a great believer in charts," Rocky says. Sometimes he orders "special issues" of his notebook to chart broad topics like raw materials. "If you make a presentation to him on charts," says an aide, "he'll love it. You could lie to him very easily with charts. He thinks that if you can present it graphically, it must be true."

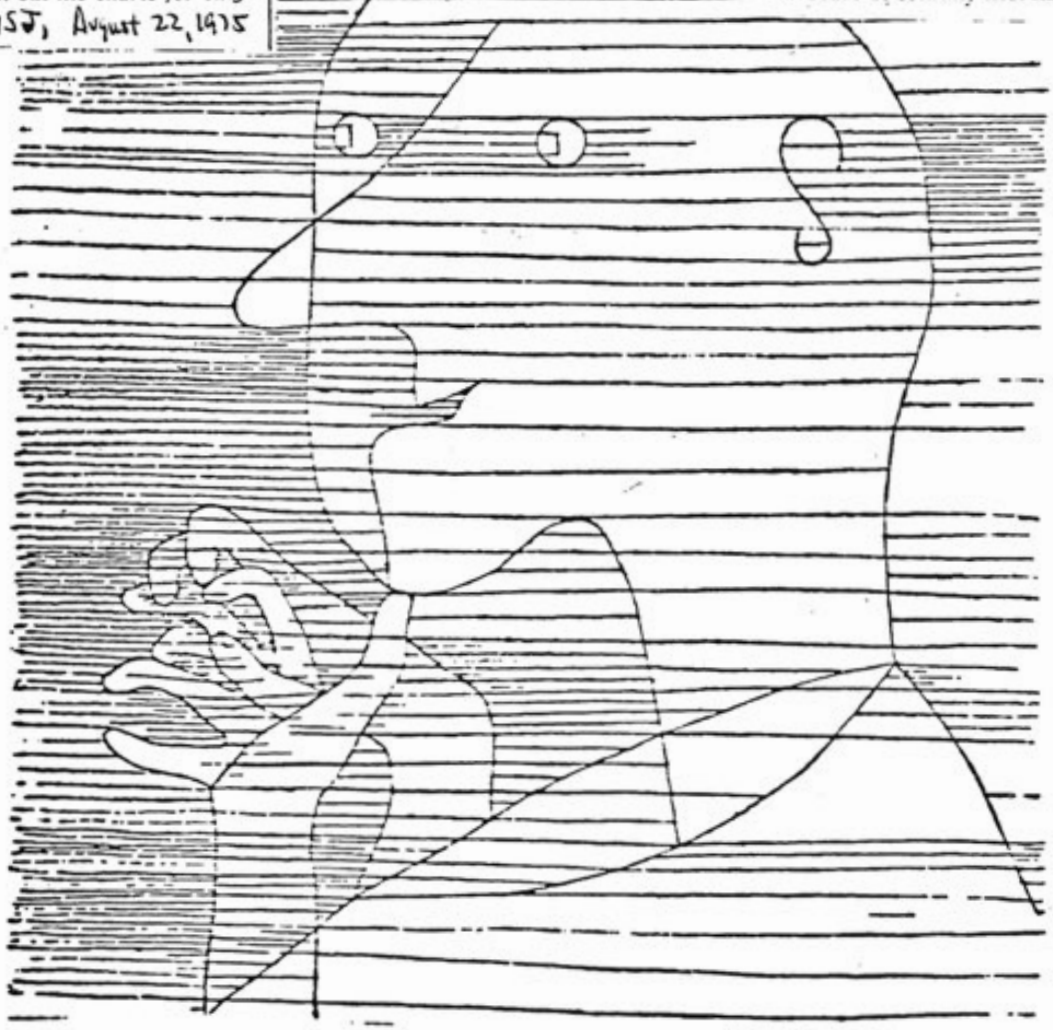
*Rocky boasts that a production breakthrough makes it possible for a computer to turn out his charts for only $5 apiece.* WSJ, August 22, 1975

**PROFITS**

Over the past fifteen years our profits have increased by a modest 75 million dollars. The diagram below



depicts, from left to right, three light bulbs of steadily increasing size.



Paul Klee, "Old Man Figuring," etching, 1929, Collection, Museum of Modern Art, New York. This etching appeared on the cover of the December, 1973 Monthly Labor Review.

CONTENTS

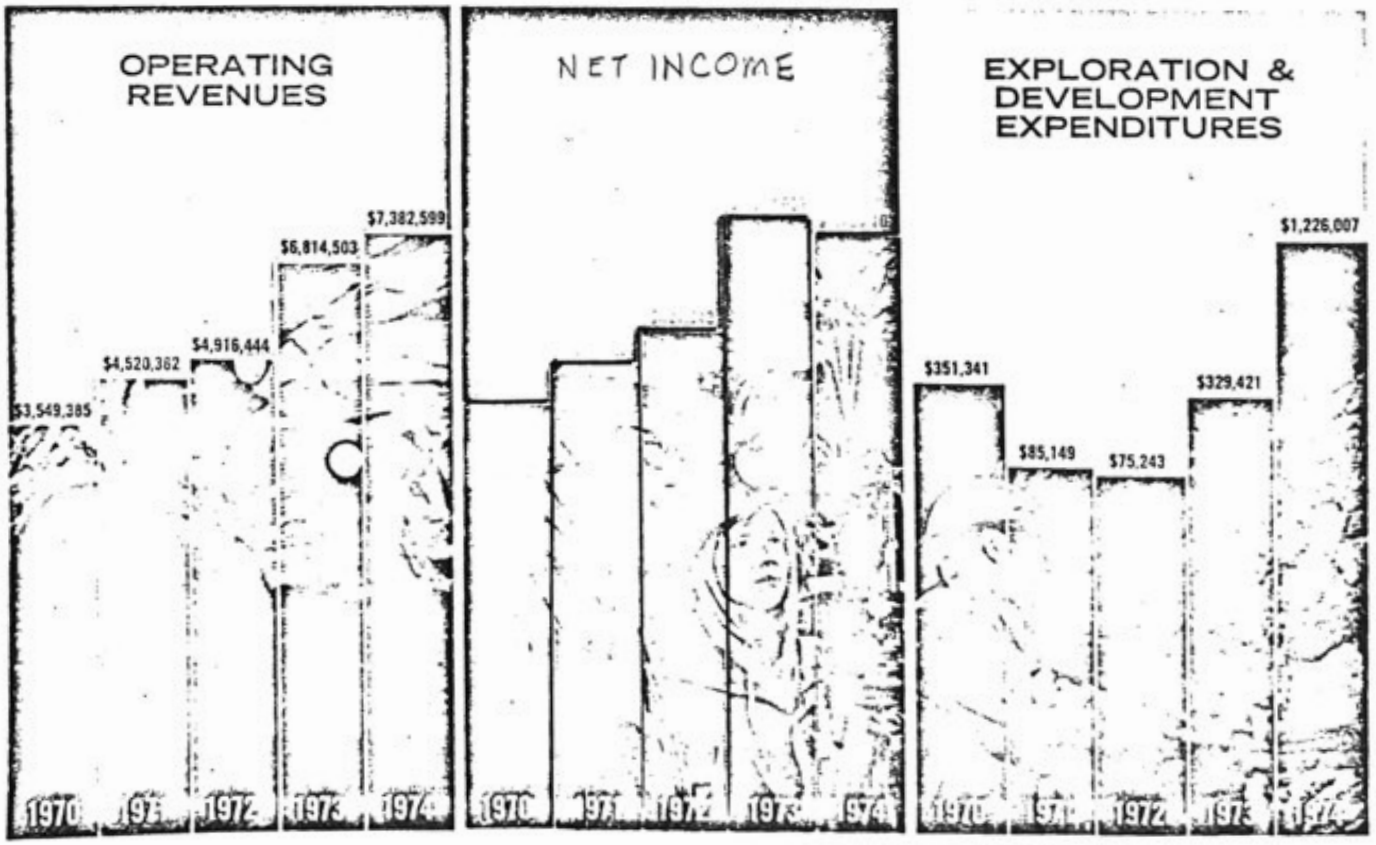
# Financial Highlights for the Past Five Years

| | 1974 | 1973* | 1972* | 1971* | 1970* |
|---|---|---|---|---|---|
| Operating revenues | $7,382,599 | $6,814,503 | $4,916,444 | $4,520,362 | $3,549,385 |
| Operating expenses | 5,311,439 | 4,590,340 | 4,119,979 | 3,946,451 | 3,735,699 |
| Income (loss) before income taxes | 2,071,160 | 2,224,163 | 796,465 | 573,911 | (186,314) |
| Provision (credit) for income taxes | 636,058 | 577,162 | 274,522 | 176,164 | (175,300) |
| Net income (loss) | $1,435,102 | $1,647,001 | $ 521,943 | $ 397,747 | $ (11,014) |
| Earnings per share | $0.49 | $0.56 | $0.18 | $0.14 | .... |
| Dividends per share | $0.10 | $0.10 | $0.10 | $0.05 | .... |
| Average number of shares outstanding | 2,919,644 | 2,930,786 | 2,924,252 | 2,919,536 | 2,919,536 |
| Exploration and development expense | $1,226,007 | $ 329,421 | $ 75,243 | $ 85,149 | $ 351,341 |
| Number of shareowners at year end | 6,955 | 6,687 | 6,404 | 6,469 | 6,634 |
| Working capital at year end | $5,293,900 | $4,507,858 | $2,461,520 | $1,914,381 | $1,915,017 |

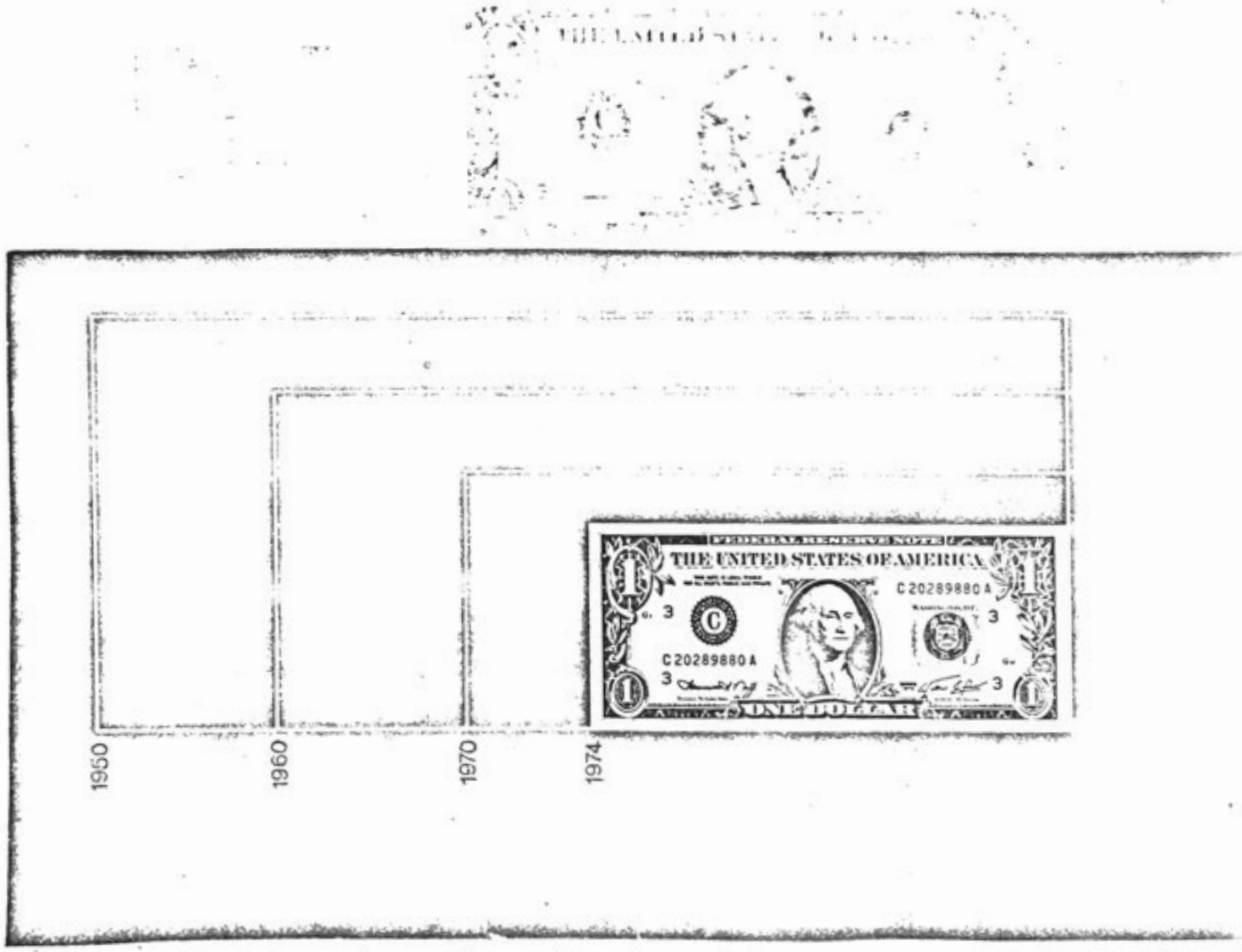
*See Note 1 to Financial Statements

# Comparative Stock Prices and Dividends Paid

| | 1974 | | | 1973 | | |
|---|---|---|---|---|---|---|
| | Share Prices | | Dividends | Share Prices | | Dividends |
| | High | Low | Paid | High | Low | Paid |
| First Quarter | 19¼ | 9 | .... | 9⅞ | 7⅞ | .... |
| Second Quarter | 10⅝ | 6⅝ | 0.10 | 10 | 7⅝ | .... |
| Third Quarter | 10⅛ | 3⅝ | .... | 9⅞ | 6½ | .... |
| Fourth Quarter | 8⅛ | 4¾ | .... | 8⅝ | 6¼ | 0.10 |



The old goose-up by squaring the eyeball trick.




First Pennsylvania Corporation, Annual Report, 1974.

THE WORD-WORTH OF ONE PICTURE

Contemplate the news report; then the graph on the following page.

(The news report is 700 words long.)

*THE NEW YORK TIMES, MONDAY, JUNE 2, 1975*

# FRANKED MAIL TIE TO VOTING SHOWN

## Testimony Finds the Volume Rises Before Elections

WASHINGTON, June 1 (AP) —New court testimony and documents show that much of the mail Congress sends at taxpayer expense is tied directly to the re-election campaigns of Senate and House members. According to material filed in a lawsuit in Federal Court:

¶Senate Republicans put two direct-mail experts on the public payroll to advise them on how to use their free mailing privileges to get votes.

¶An election manual prepared for Senate Democrats refers to newsletters as a "free forum," and sets up a timetable for sending them as an integral part of a model re-election campaign.

¶Senator John G. Tower, Republican of Texas, mailed more than 800,000 special-interest letters at taxpayer expense as part of his 1972 re-election effort and received campaign volunteer offers and donations in response.

¶Senator Jacob K. Javits, Republican of New York, gave written approval in 1973 for a tax-paid mail program intended to better his image and pay off at the polls. He focused his mail on areas where he needed votes.

¶The volume of "official" Congressional mail rises in election years and peaks just before the general election.

None of this activity necessarily violates any law or regulation, since Congress has wide discretion in the use of tax-paid mail. Congress gave itself the right to send official mail at Government expense at the founding of the republic, and only Congress polices against abuses of the free mailings.

Complaints of political use of the free-mailing privilege, called the franking privilege, are heard every election year. Recently, however, the volume and cost of franked mail has multiplied. A new Federal law will limit what out-of-office challengers can spend to unseat incumbents.

In 1972, Congress passed a law prohibiting mass franked mailings within 28 days before an election. The sponsor of that legislation, Representative Morris K. Udall, Democrat of Arizona, said in an interview that further changes were needed to curtail political abuse of the frank.

Mr. Udall urged a 60-day pre-election cutoff for mass mailings and said he favored closing a loophole that recently allowed defeated Representative Frank M. Clark, Democrat of Pennsylvania, to send a franked newsletter to his old constituents after he had left office. Mr. Clark is seeking to regain his old post.

### Practice Documented

Seldom has the political use of franked mail been so well documented as in recent testimony and documents filed in a Federal Court by Common Cause, the lobby group, which is suing for an end to tax-financed mass mailings by Congress.

For example, Joyce P. Baker, a political mail specialist, said in a 1973 job proposal that she wanted to set up direct-mail programs for Republican Senators using franked mail.

"The purpose of such a program is to help an incumbent Senator get re-elected," she said.

She was put on the Senate payroll at $18,810 a year in 1973 and 1974 and testified that during that time she aided Republican Senators Robert J. Dole of Kansas, Peter H. Dominick of Colorado, Charles McC. Mathias Jr. of Maryland and others.

Another political mail specialist, Lee W. MacGregor, wrote a proposal for the use of franked mail by his chief, Senator Javits, in 1973.

"The over-all objective of the franked mail program can be to get the recipient of the mail to identify positively with a particular stand you have taken or a bill you have introduced; the kind of identification that can be translated into a vote at the polls on election day," Mr. MacGregor said.

Mr. Javits was out of the country and could not be reached. His administrative assistant, Donald Kellerman, defended the use of franked mail.

"It is a standard device to let voters, not voters but citizens, know what the Senator is doing here in Washington," he said.

Senator Tower's use of franked mail in his 1972 campaign was documented by memorandums.

Tom Loeffler, a high-ranking campaign aide, wrote in a memorandum dated Oct. 27, 1972, that during the campaign Senator Tower had sent "31 special interest letters totaling approximately 803,333 franked mailings."

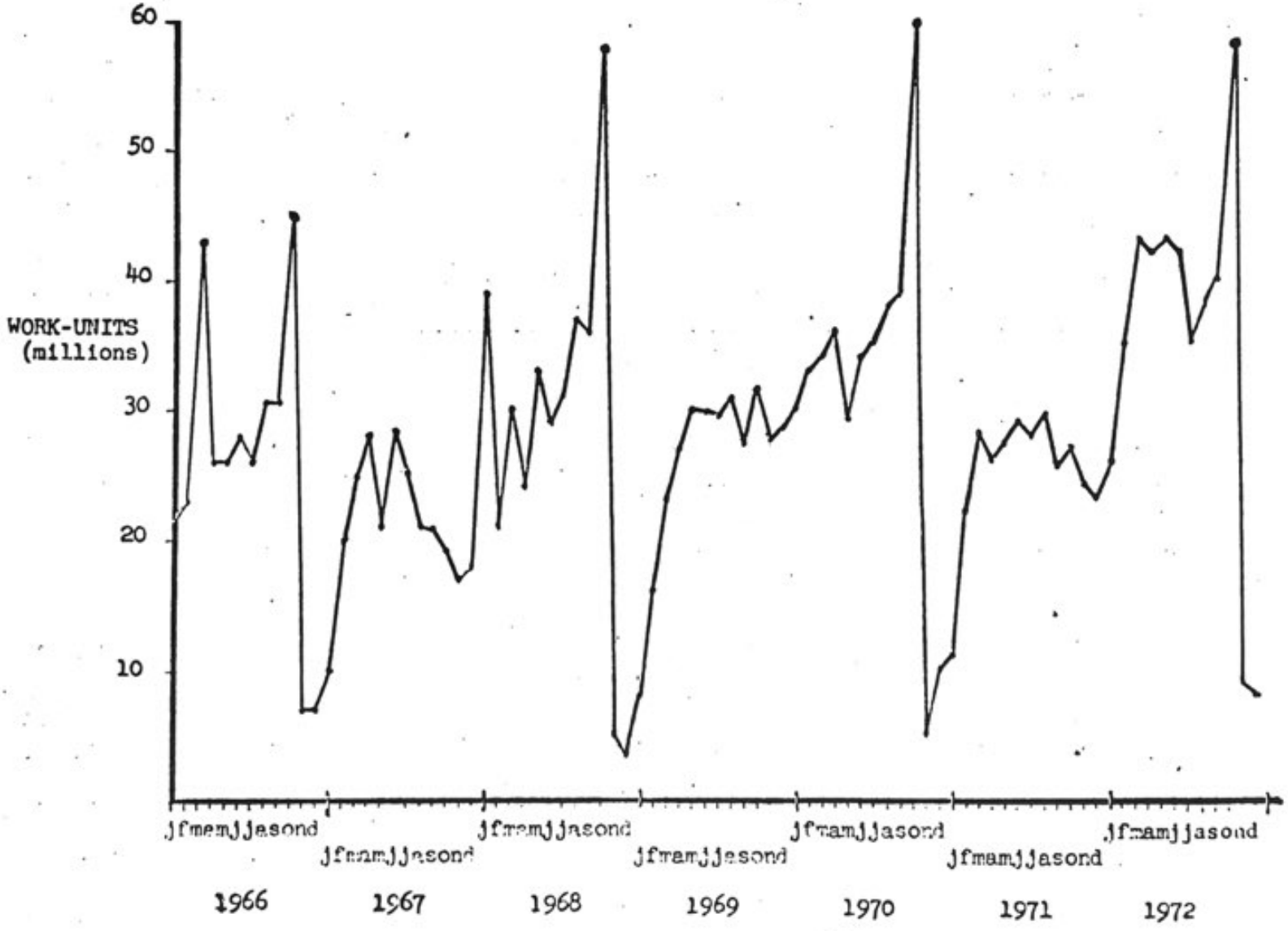
Mr. Tower was not available for comment. His administrative assistant, Elwin Skiles, said the Senator's use of franked mail in 1972 was within the law, and he defended the free-mailing privileges.

"It's certainly a vital way to keep your constituents informed about what's happening," Mr. Skiles said.

Postal Service figures show that in the 12 months before November, 1973, Congress sent 222.9 million franked pieces of mail. But in the next 12 months, covering the election season of 1974, Congress sent 350.6 million, a jump of 57 per cent.

U.S. HOUSE OF REPRESENTATIVES: PUBLICATIONS DISTRIBUTION SERVICE,

MILLIONS OF WORK-UNITS PER MONTH, 1966-1972



THE LOUSY COMPONENT BAR CHART

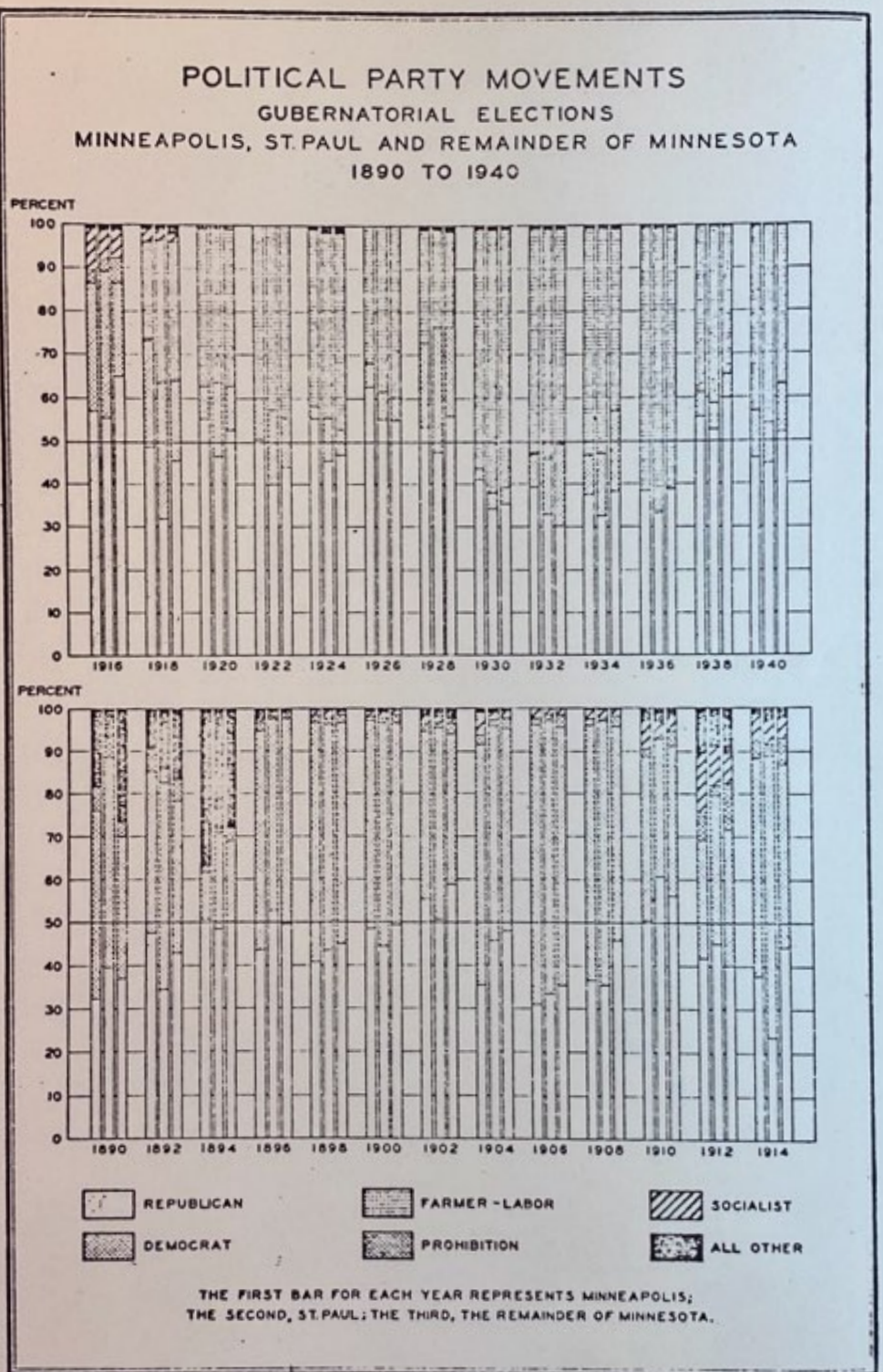
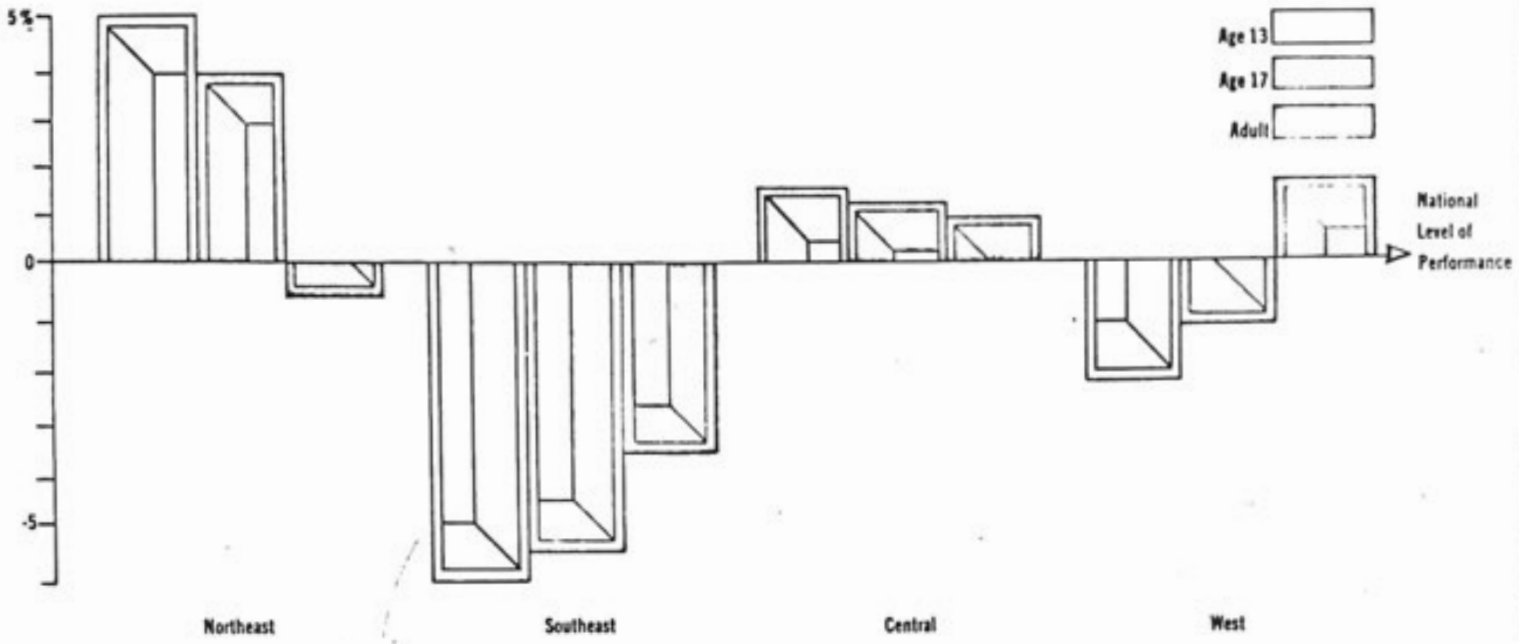



Figure 68. Grouped One-Hundred Percent Column Chart Portraying Time Series.



Source: Calvin F. Schmid, Handbook of Graphic Presentation (New York: Ronald Press, 1954), p. 101.

MEDIAN DIFFERENCES FROM NATIONAL PERFORMANCE BY REGION




Source: Office of Education, HEW, American Education, October, 1975, p. 23.

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MALE-FEMALE DIFFERENCES: CONSUMER-COST PROBLEMS

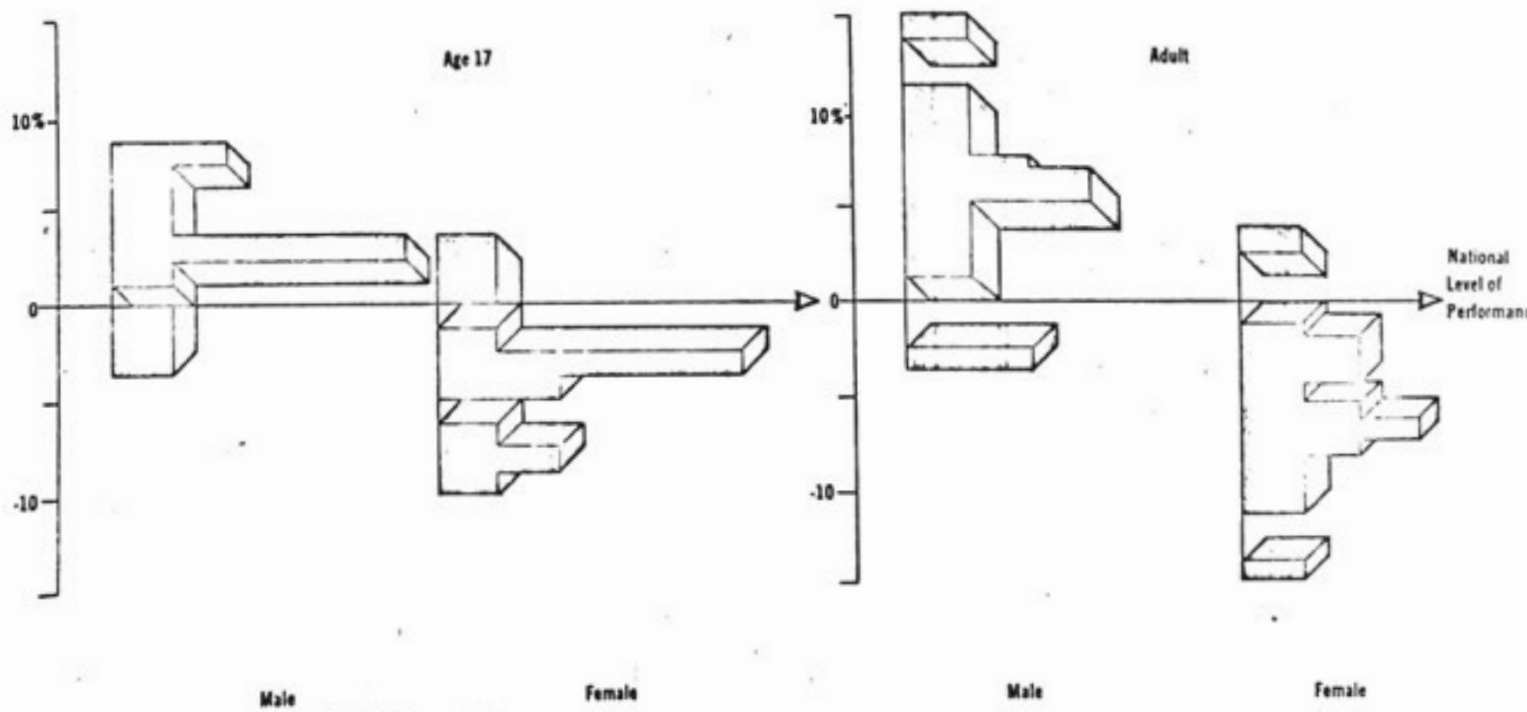
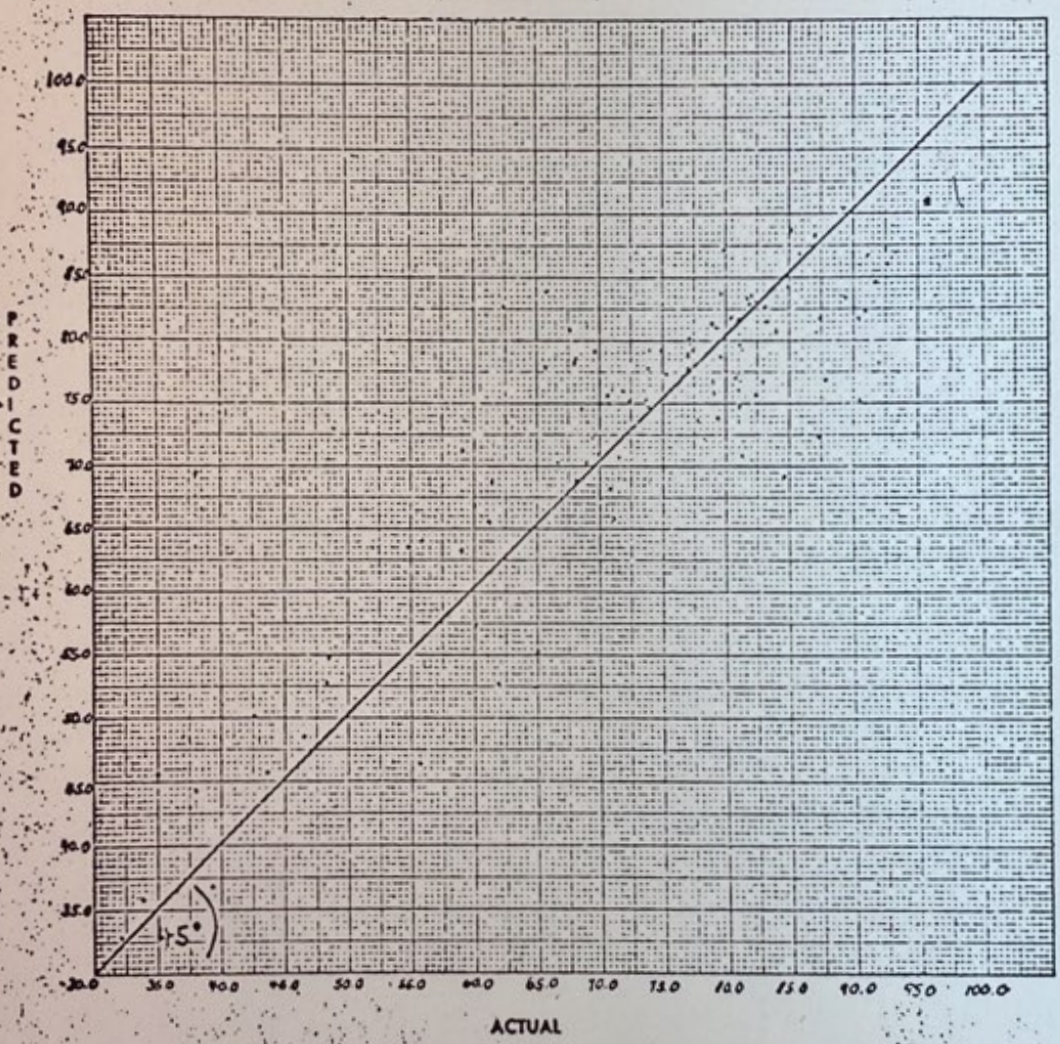
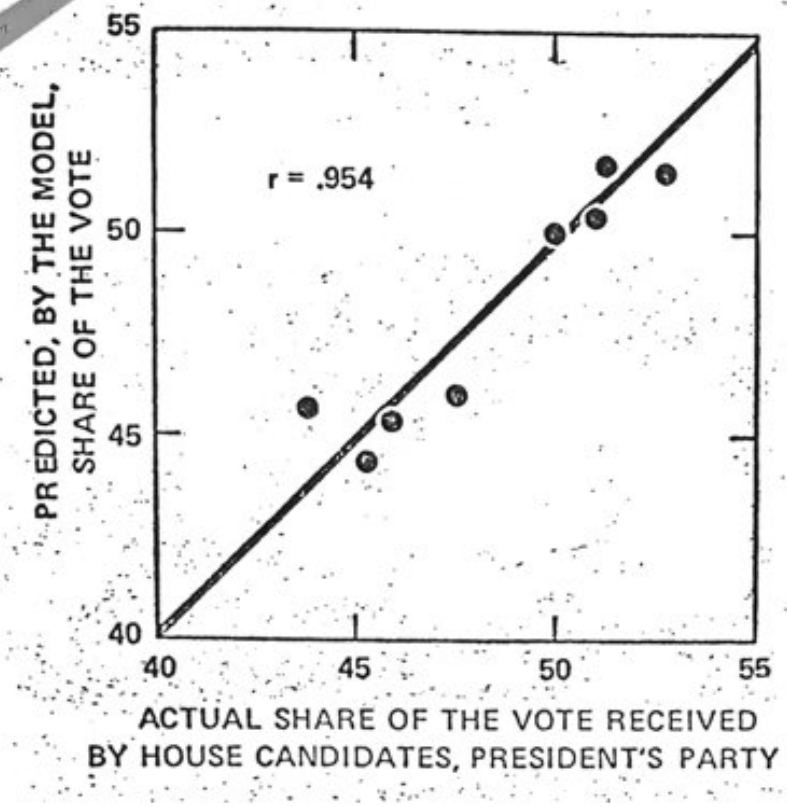


FIG. 1. Relationship of Actual Rates of Registration to Predicted Rates (104 cities 1960).




align letter

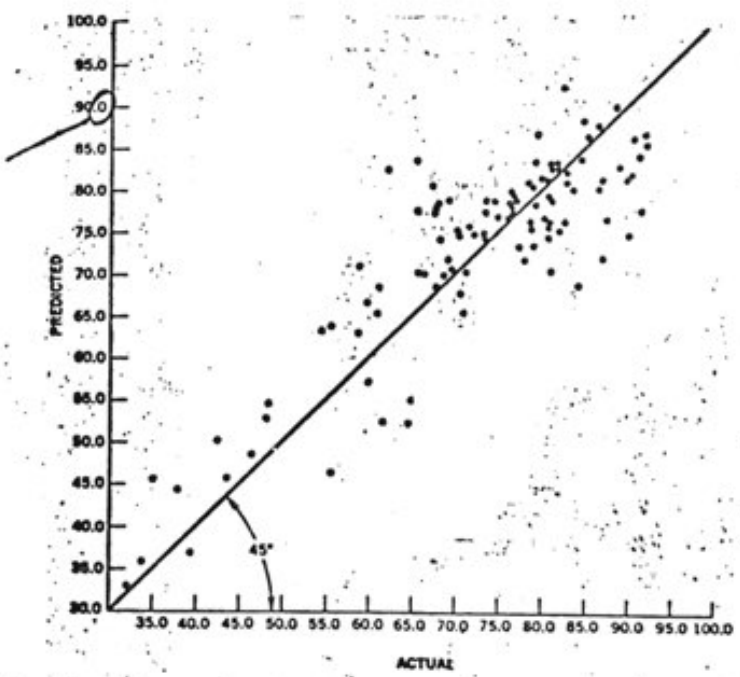
Source: Stanley Kelley, Jr., Richard E. Ayres, and William G. Bowen, "Registration and Voting: Putting First Things First," American Political Science Review, 61 (June, 1967), p. 371.




ACTUAL AND PREDICTED SHARE OF THE TWO-PARTY VOTE RECEIVED BY CONGRESSIONAL CANDIDATES OF PRESIDENT'S PARTY

Source: Edward R. Tufte, "Determinants of the Outcome of Midterm Congressional Elections," American Political Science Review, 69 (September, 1975), p. 818.

extra digits not needed; ".0" should be deleted from each number




Relationship of Actual Rates of Registration to Predicted Rates (104 cities 1960).

Source: Stanley Kelley, Jr., Richard E. Ayres, and William G. Bowen, "Registration and Voting: Putting First Things First," American Political Science Review, 61 (June, 1967); figure from reprinted version in Edward R. Tufte, ed., The Quantitative Analysis of Social Problems (Reading, Massachusetts: Addison-Wesley, 1970), p. 267.

Finally, here is a third version of the same scatterplot; this time as it was published in William J. Crotty, ed., Public Opinion and Politics: A Reader (New York: Holt, Rinehart and Winston, 1970), p. 364.

Figure 19.1 Relationship of Actual Rates of Registration to Predicted Rates (104 cities, 1960)

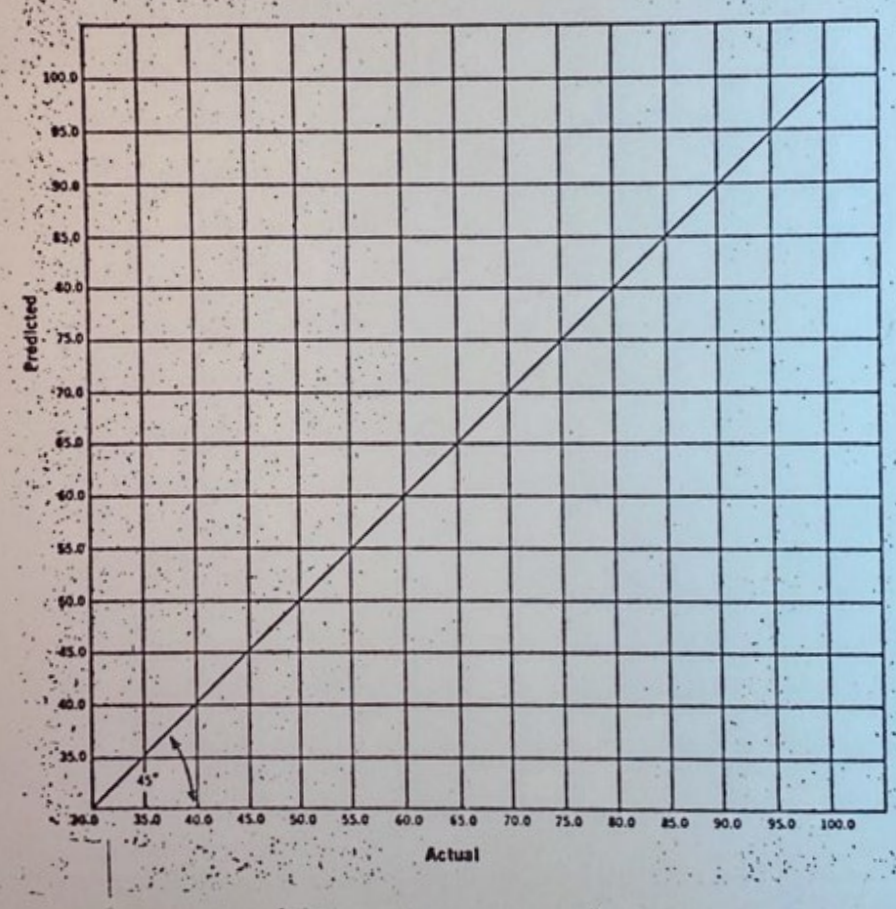
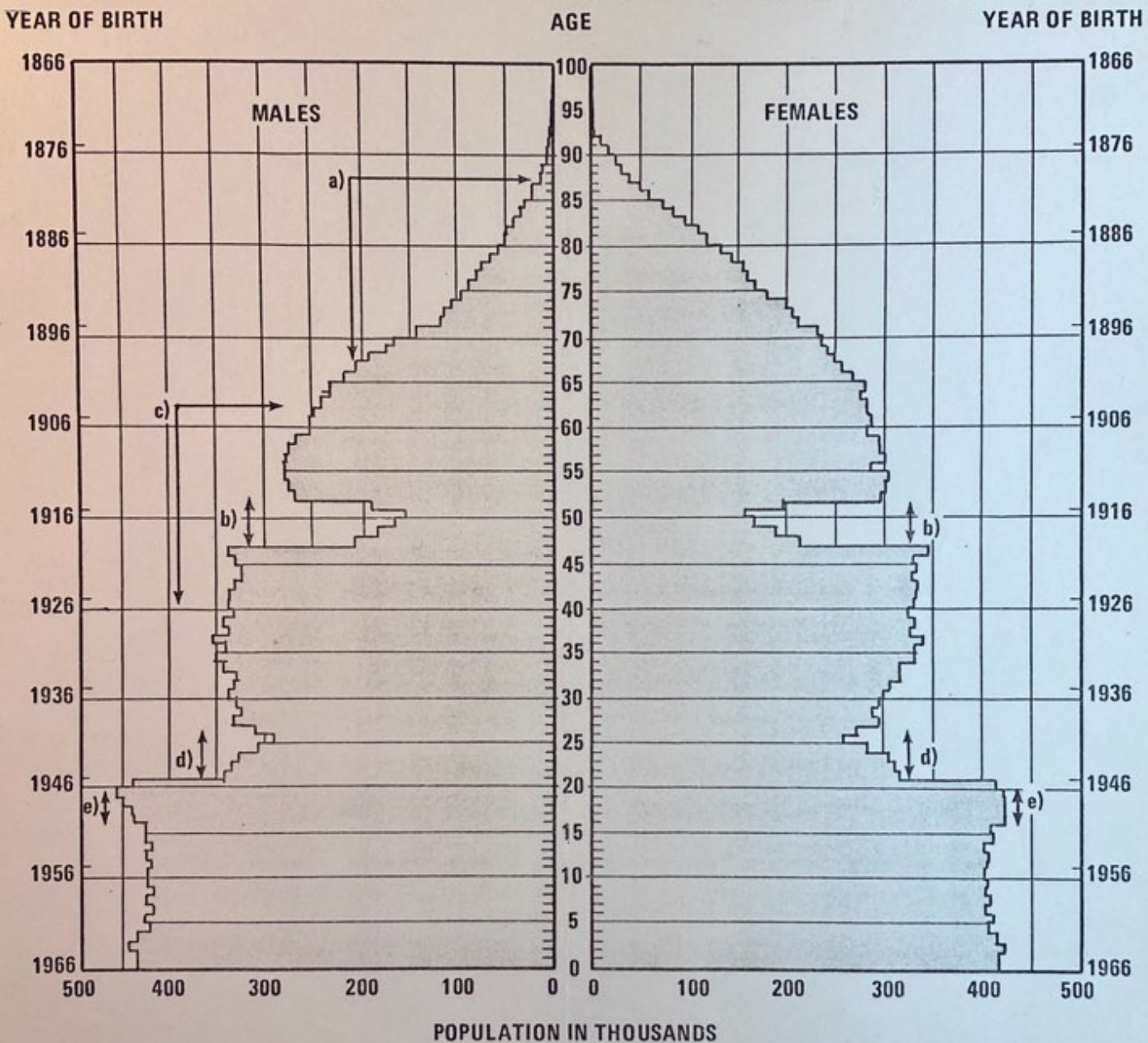


Figure 8–15.—Population of France, by Age and Sex: January 1, 1967




(a) Military losses in World War I
(b) Deficit of births during World War I
(c) Military losses in World War II
(d) Deficit of births during World War II
(e) Rise of births due to demobilization after World War II

Source: Based on France, Institut national de la statistique et des études économiques *Annuaire statistique de la France, 1967*, 1968, p. 33.

New York Times, February 1, 1976

# BLOT MAPS

12

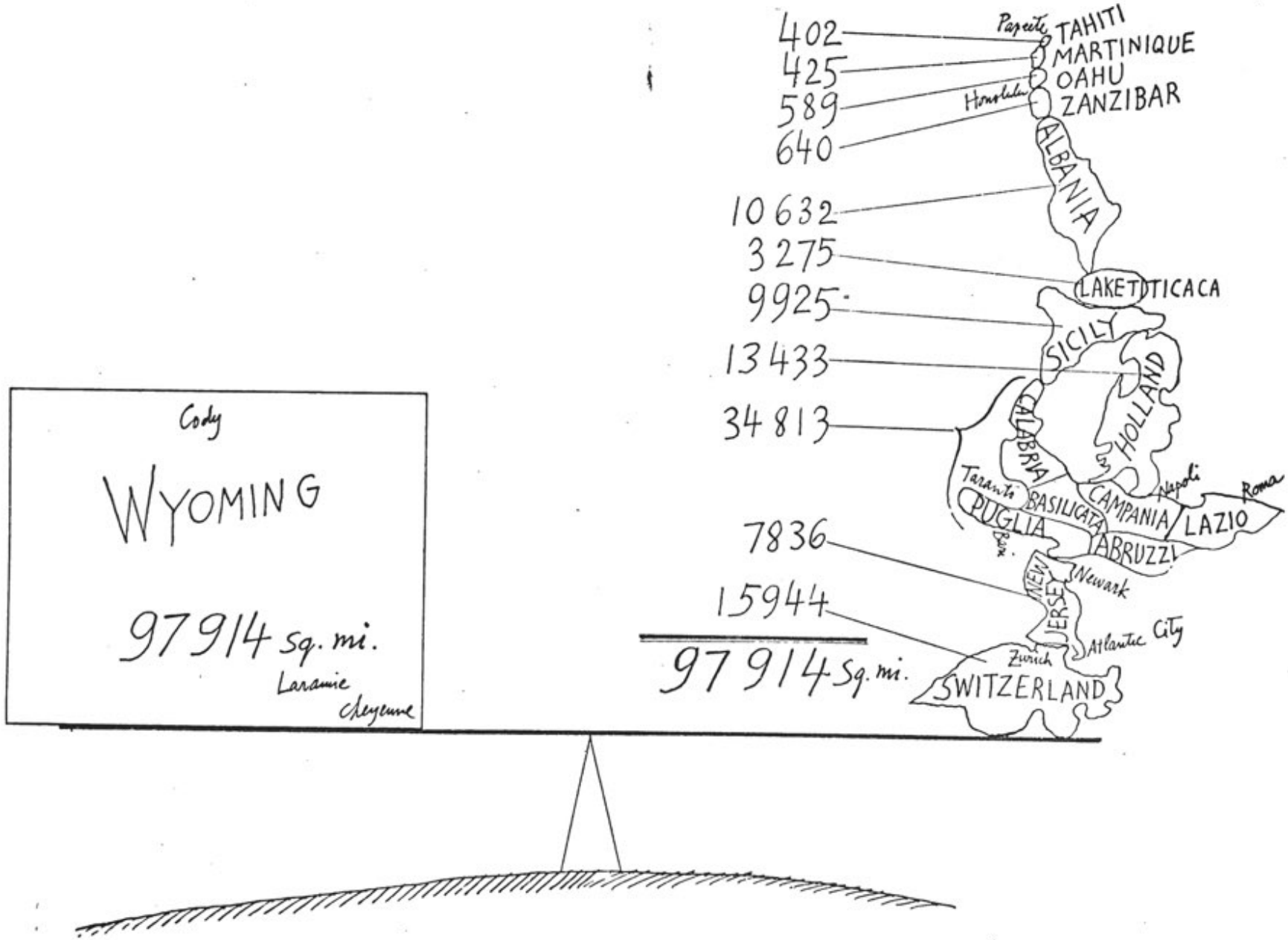
THE NEW YORK TIMES, SU

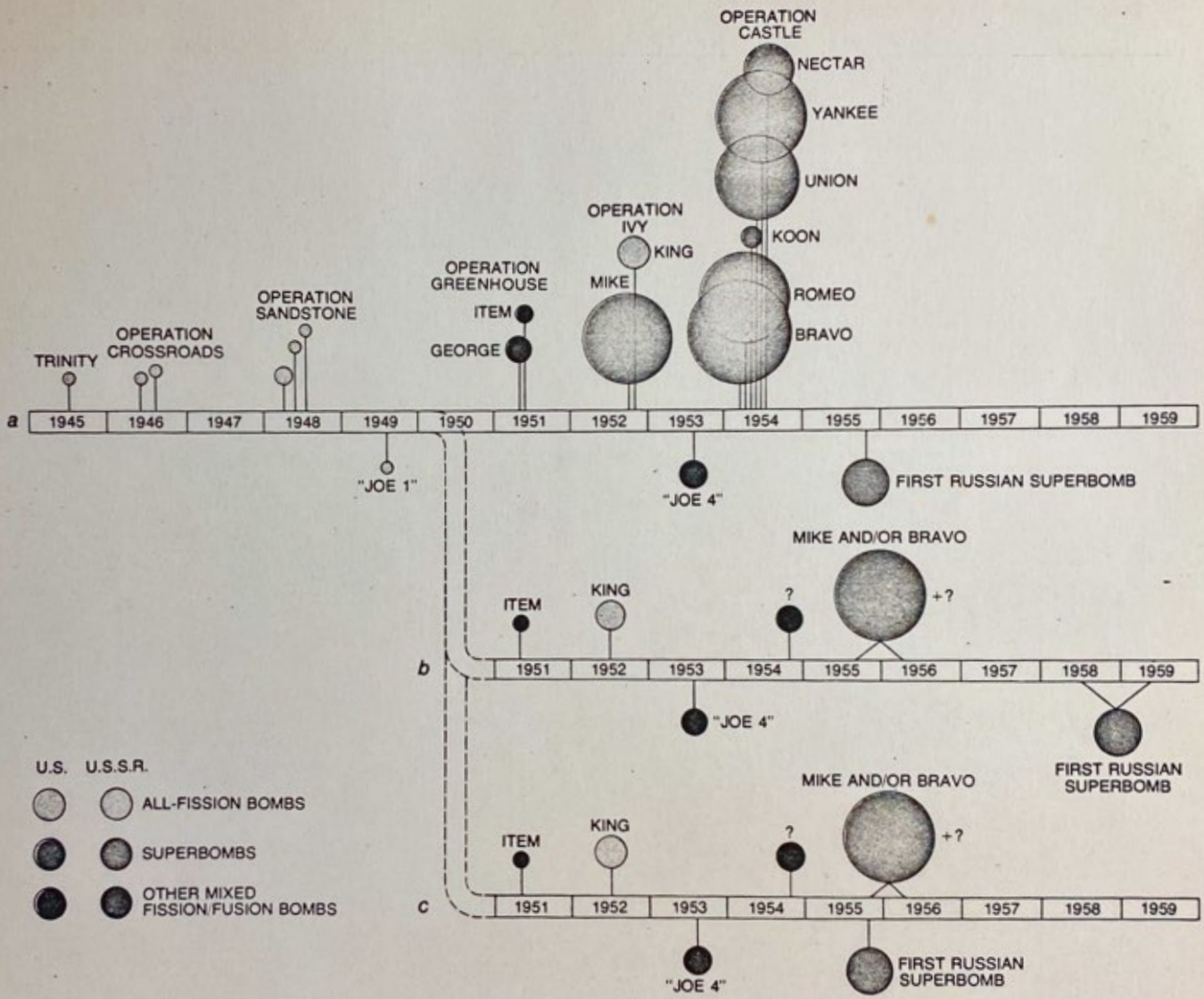

More Elderly Are Retiring in the North

| California | Arizona | Utah | Nevada |
|---|---|---|---|
| Amador | Mohave | Washington | Chuuchill |
| Calaveras | Yavapai | | |
| Inyo | Yuma | | |
| Mariposa | Graham | Wyoming | |
| Mono | | | |
| Tuolumne | | Campbell | |

90% visual effect
.14% of the people

AND WHAT IS WRONG WITH BLOT MAPS


Cody
WYOMING
97914 sq. mi.
Laramie
Cheyenne
402
425
589
640
10632
3275
9925
13433
34813
7836
15944
97914 sq. mi.
Papeete
TAHITI
MARTINIQUE
OAHU
Honolulu
ZANZIBAR
ALBANIA
LAKE TITICACA
SICILY
HOLLAND
CALABRIA
Taranto
BASILICATA
CAMPANIA
Napoli
Roma
LAZIO
PUGLIA
ABRUZZI
Bari
Newark
Atlantic City
Zurich
SWITZERLAND




**TWO HYPOTHETICAL OUTCOMES** are postulated in an effort to evaluate how much risk would have been involved in a U.S. decision not to proceed with the superbomb. They are depicted in this historical chart as branches of the time line representing the actual world (*a*). The first branch is referred to by the author as the "most probable alternative world" (*b*), the second as the "worst plausible alternative world" (*c*). Both branches originate at January, 1950, the date President Truman announced his decision to go ahead with the superbomb. The circles denote nuclear-test explosions; the labels are U.S. code names. Area of each circle is proportional to the region that could be destroyed by that bomb. Bombs of "nominal" size (less than 50 kilotons) have been omitted after 1950.



Source: Herbert F. York, "The Debate Over the Hydrogen Bomb," Scientific American, 233 (October, 1975), p. 110.

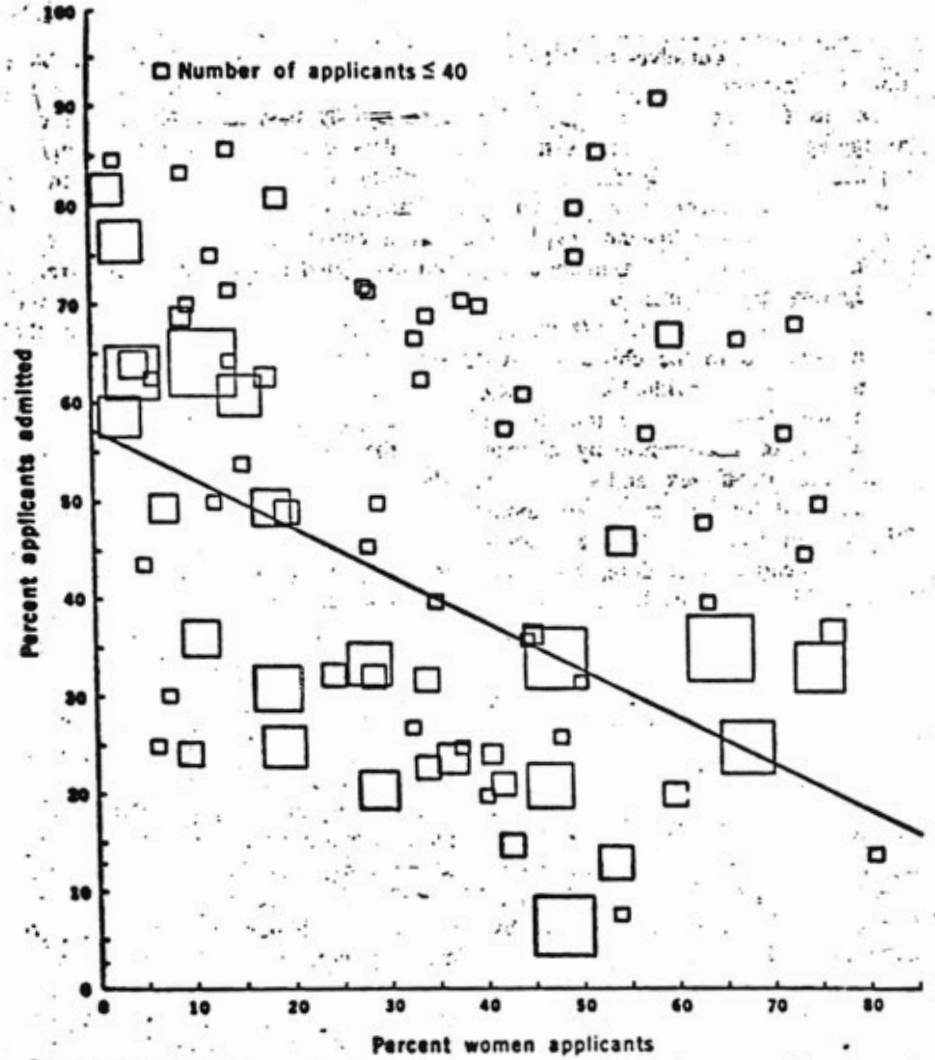



Fig. 1. Proportion of applicants that are women plotted against proportion of applicants admitted, in 85 departments. Size of box indicates relative number of applicants to the department.

Source: P. J. Bickel, E. A. Hammel, and J. W. O'Connell, "Sex Bias in Graduate Admissions: Data From Berkeley," Science, 187 (February 7, 1975), p. 400.

No detailed scale for size of box given. One possibility: five biggest boxes might be labeled and the Department name and N given at the side of the graph in a legend.

Why should minimum box size be for N ≤ 40?

Fig. principle is directly violated in caption.

Fitted line does not fit the data. At a minimum, scale at low end should be stretched.

Might try two different styles of boxes: one with internal shading, one without. Then at least a dichotomy by type of department could be displayed.

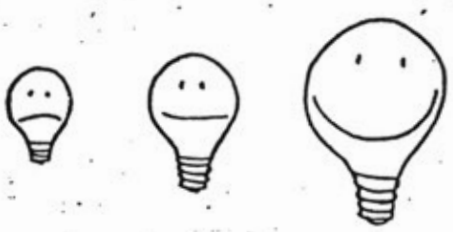
Lettering quality poor; lettering did not shrink well.

INTEGRATION OF WRITTEN TEXT AND GRAPHS

The means of printing production have caused written text and graphs to become alienated from one another. Can graphs (and tables) and written text flow more naturally into one another than they do now? This good example

**Profits**

Over the past fifteen years our profits have increased by a modest 75 million dollars. The diagram below



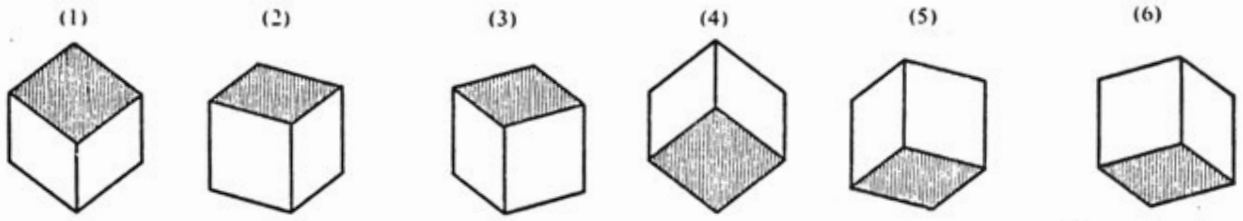
depicts, from left to right, three light bulbs of steadily increasing size.

of text-picture integration shows a graceful flow, except the pointer word "below" can be eliminated. After all everybody can tell where the diagram is; also the pointer word serves to separate text and diagram. We would never write "The sentence below shows such-and-such in more detail;" but some have written "Figure 17 shows such-and-such ..."

Why do all figures have to be numbered and set aside from the text? Figures are usually not substantively separate from the text; so they need not be divorced from the text? The same goes for tables.

Can some examples be found?

# Small Multiples




Axes are positioned as shown in (1)–(6). For each position, the object may be placed on each of six faces and rotated 90° CCW as shown in columns (a)–(d). For each position of axes, we show 24 *different* views of the object. Six axes positions yield 6 X 24–or 144 different views. Choosing a different set of axes results in a completely different set of 144 views.

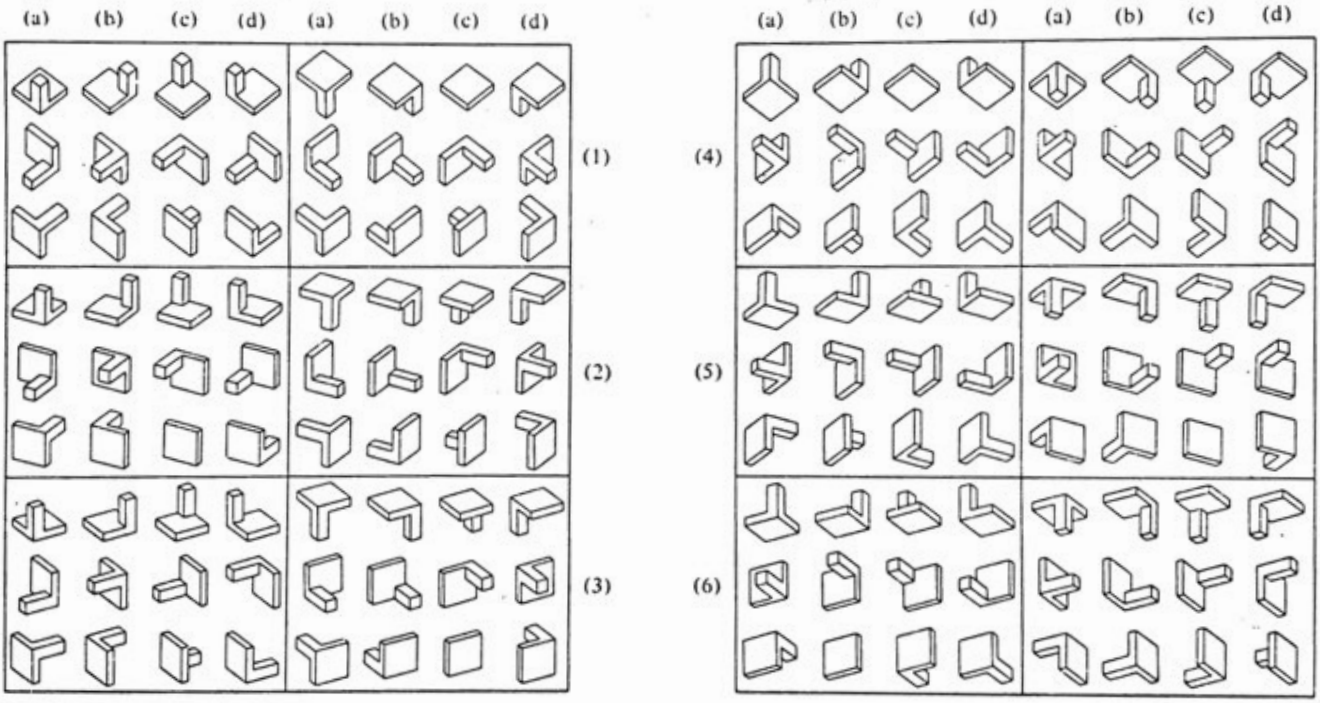



**Figure 2.39** The 144 different views of an object in dimetric using *one* set of axes for *one* object.

Source: George E. Morris, Technical Illustrating (Englewood Cliffs, New Jersey: Prentice-Hall, 1975), p. 35.

≠2, April

BIOLOGY 12, 154–159 (1975)

18

# Analysis of Freezing Temperature Distribution in Plants

SHOSUKE KAKU

*Biological Laboratory, College of General Education, Kyushu University, Ropponmatsu, Fukuoka 810, Japan*

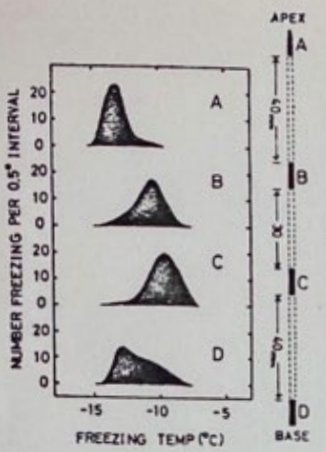



FIG. 1. Frequency distribution curves for freezing temperatures of 10-mm needle pieces obtained from different parts of mature *Pinus* needles, 150 mm in length, and the location of the needle pieces used as the material: (A) apical portion of needles; (B) middle portion of needles, 50 mm distant from the apex of needles; (C) middle portion of needles, 50 mm distant from the base of needles; (D) basal portion of needles.

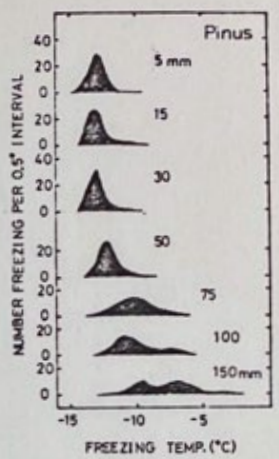



FIG. 2. Frequency distribution curves for freezing temperatures of mature *Pinus* needles cut to various lengths from 5 to 150 mm.

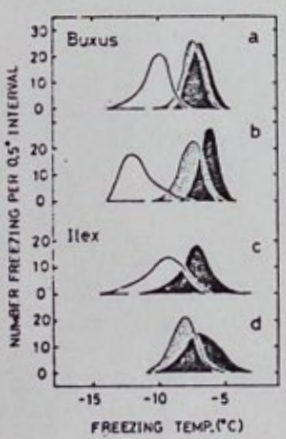



FIG. 4. Changes of frequency distribution curves for freezing temperatures accompanying leaf maturation in *Buxus* (a, b) and *Ilex* (c, d) leaves. Black indicates mature leaves; stippling, semimature ones; plain, immature ones. Samples used in each experiment were as follows. (a) *Buxus* smaller leaves, each 7–15 mg in weight, April 17–30 in immature leaves, June 8–10 in semimature ones, and December 24–30 in mature ones; (b) *Buxus* larger leaves, each 50–60 mg in weight, May 2–9 in immature leaves, May 25–June 2 in semimature ones, and December 24–30 in mature ones; (c) *Ilex* smaller leaves, each 5 mg in weight, May 20–27 in immature leaves and October 8–10 in mature ones; (d) *Ilex* larger leaves, each 25 to 30 mg in weight, June 3–8 in immature leaves and October 3–8 in mature ones.

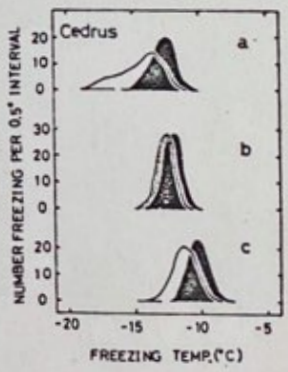
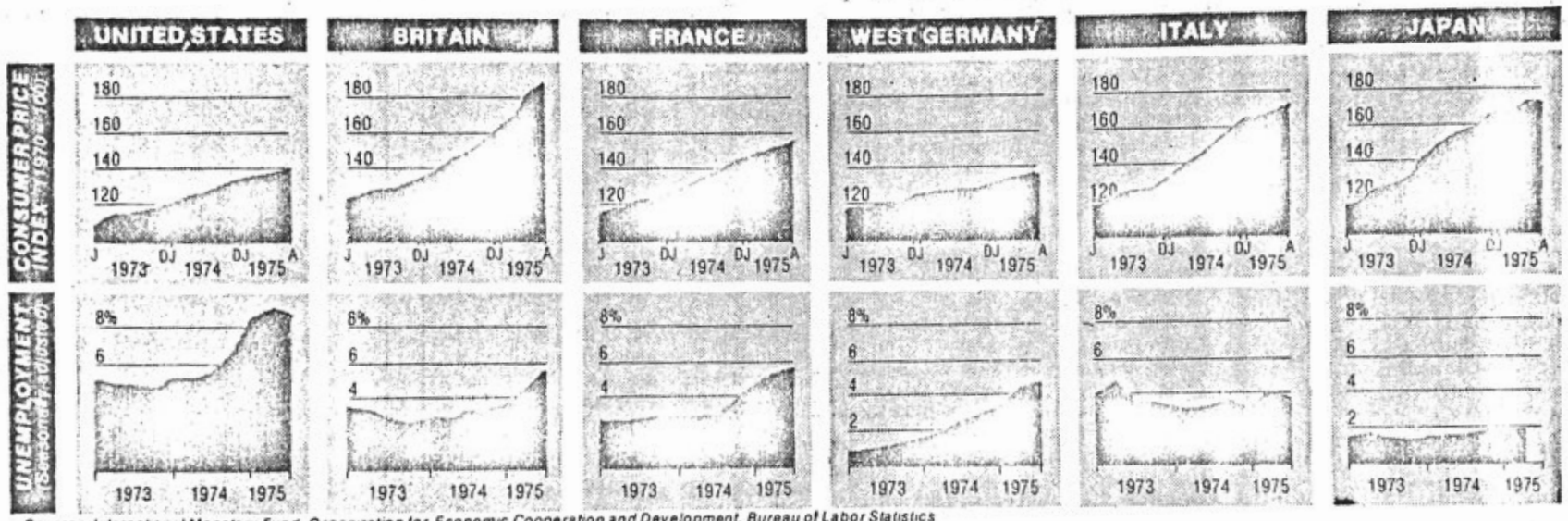



FIG. 3. Changes in frequency distribution curves for freezing temperatures accompanying maturation in *Cedrus* needles (a, b) and twigs (c). Black indicates mature needles and twigs; stippling, semimature needles; plain, immature ones. Samples used in each experiment were as follows: (a) *Cedrus* smaller needles, each 3 mg in weight and 15 mm in length, June 13–23 in immature needles; and September 23–October 1 in mature ones; (b) *Cedrus* larger needles, each 8–10 mg in weight and 30 mm in length, June 23–29 in semimature needles, and September 22–29 in mature ones; (c) *Cedrus* twigs, each 40 mg in weight, October 24–November 3 in immature and mature twigs.




Sources: International Monetary Fund, Organization for Economic Cooperation and Development, Bureau of Labor Statistics

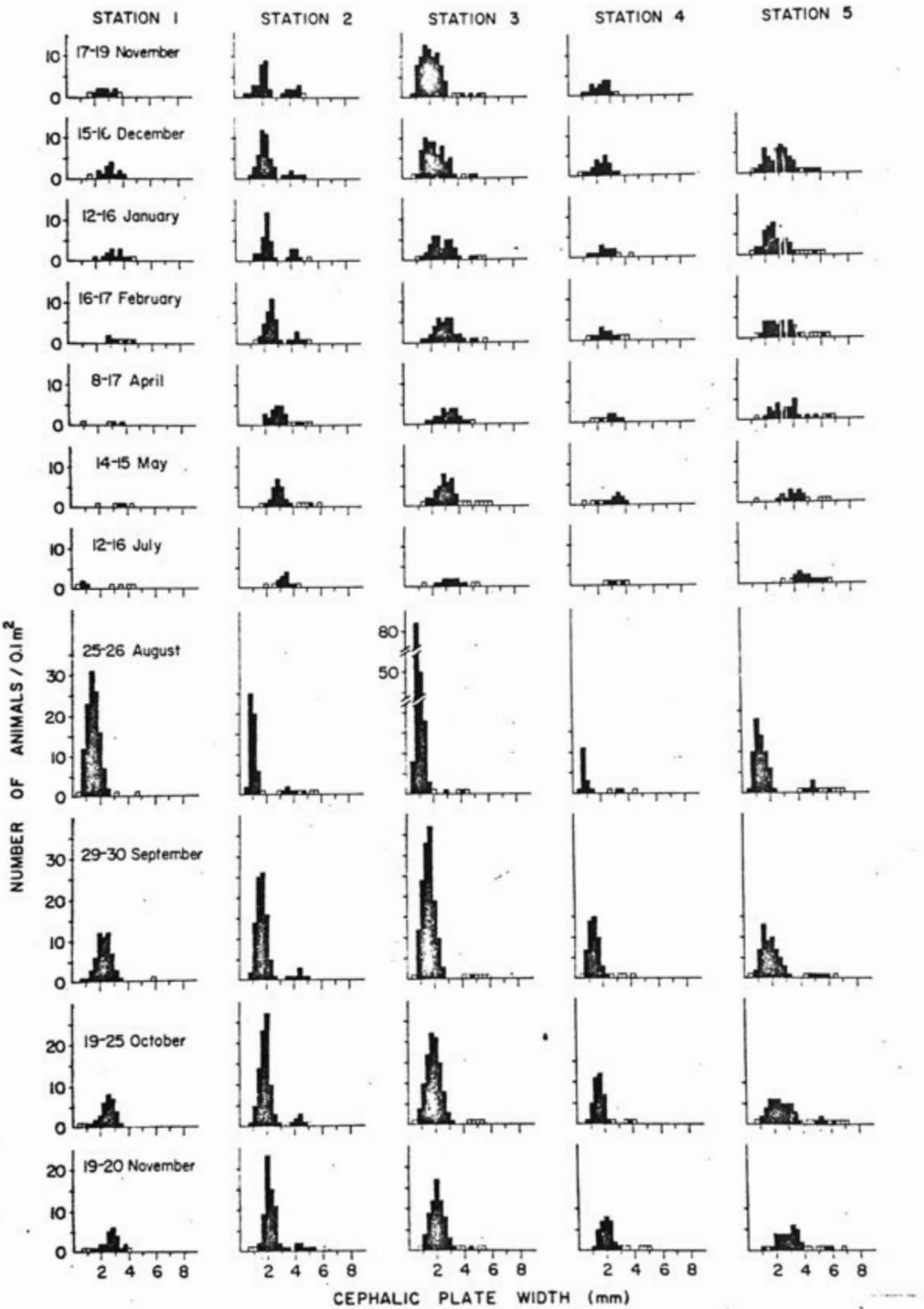



FIG. 1. Size-frequency distributions of *Pectinaria californiensis* determined from mean grab-sample data. Open squares represent occurrence of specimens in densities less than one per 0.1 m².

Source: Frederic H. Nichols, "Dynamics and Energetics of Three Deposit-Feeding Benthic Invertebrate Populations in Puget Sound, Washington," Ecological Monographs, 45 (Winter, 1975), p. 66.

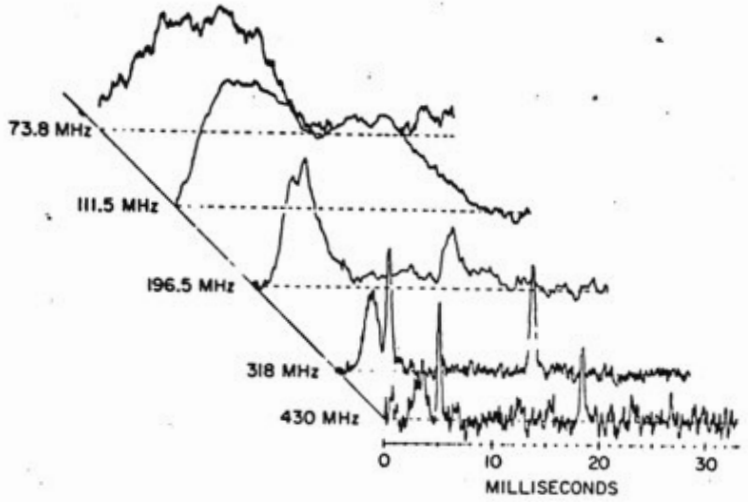



FIG. 22. Average waveforms (over about $2 \times 10^3$ periods) observed at 430, 318, 196.5, 111.5, and 73.8 MHz, from Rankin *et al.* (1970). These observations were not all simultaneous but were made on four days in 1969 between July 30 and August 22. The relative phases shown here are arbitrary. Radiometer time resolutions, in order of decreasing frequency (front to back), were 0.25, 0.42, 0.55, and 11.5 msec.

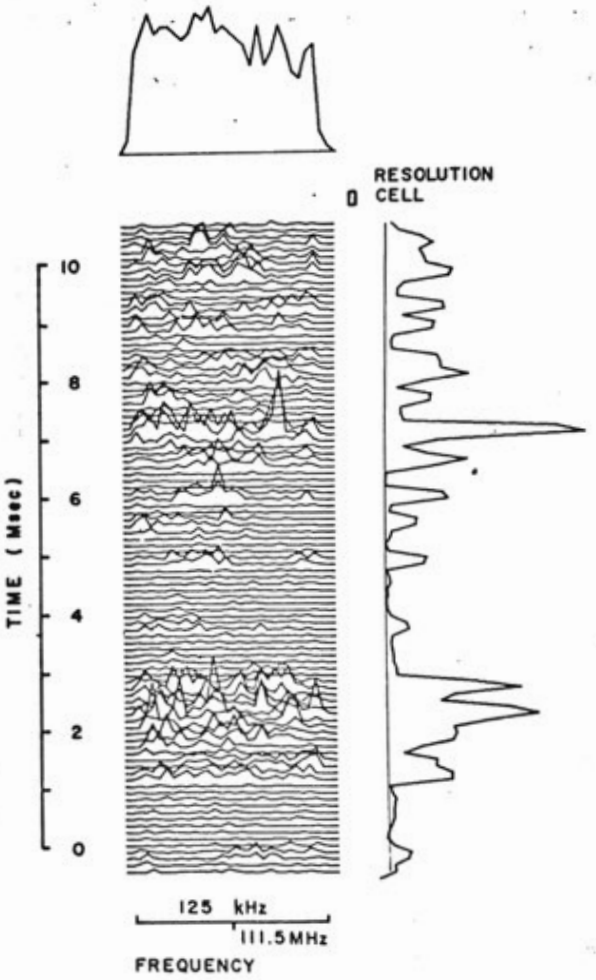
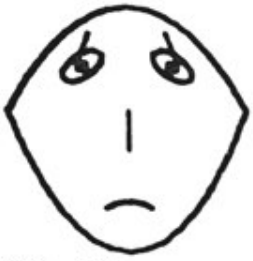



FIG. 18. Narrowband spectra of individual subpulses. Each point of the intensity $I_\epsilon(t)$ plotted on the right is the sum of the distribution of intensities across the receiver bandwidth shown in the center. At the top is plotted the spectrum averaged over the pulse. In the limit of many thousands of pulses this would show the receiver bandpass shape (Rickett and Hankins, 1973).

Source: Timonthy H. Hankins and Barney J. Rickett, "Pulsar Signal Processing," in Methods in Computational Physics, Volume 14, Radio Astronomy, eds. Benri Adler, et al. (New York: Academic Press, 1975), 108, 113.

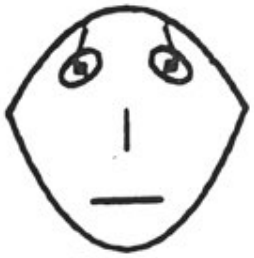
21

Chernoff-s Affect vs. 22



OBS: 37

OBS: 38



OBS: 39

OBS: 40

OBS: 41

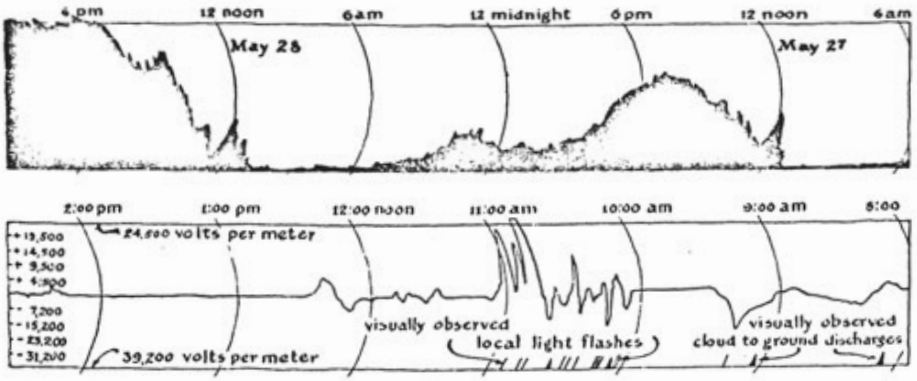
OBS: 42

OBS: 43

OBS: 44

OBS: 45

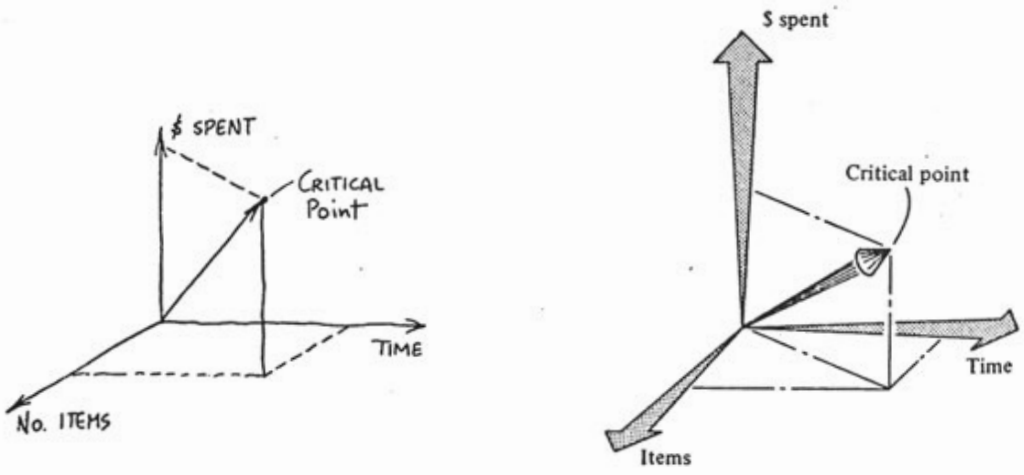
FRIENDLY LETTERING




118
Records of "sferics" *(top)* and of disturbances in the intensity of the earth's electric field *(bottom)*

285

Source: C. L. Stong, The Amateur Scientist (New York: Simon and Schuster, 1960), p. 285. Illustrated by Roger Hayward.




(a) An author's sketch

(b) An artist's version

**Figure III.4** A descriptive drawing adds flavor to an otherwise bland presentation.

Roger Hayward 24

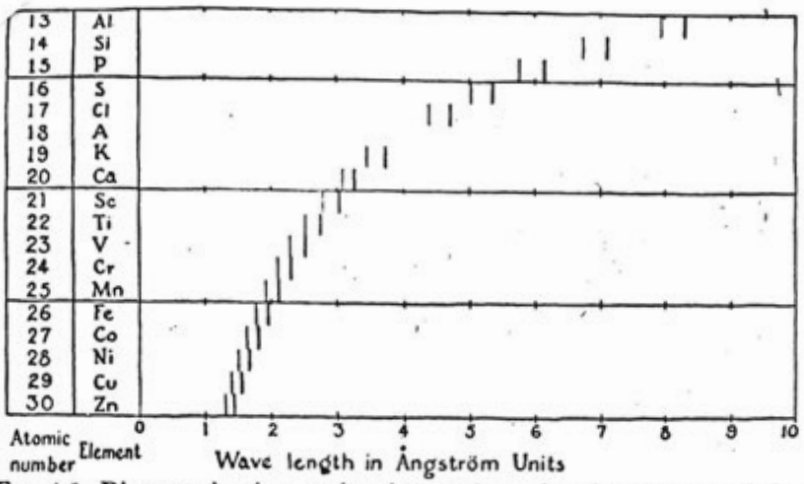



FIG. 4-1. Diagram showing regular change of wavelength of X-ray emission lines for a series of elements.

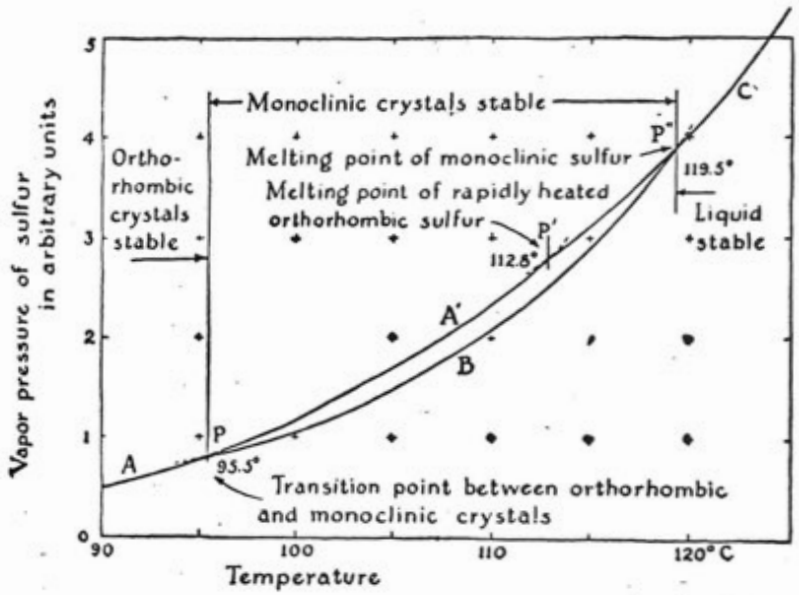



FIG. 17-2. Vapor pressure curves for sulfur.

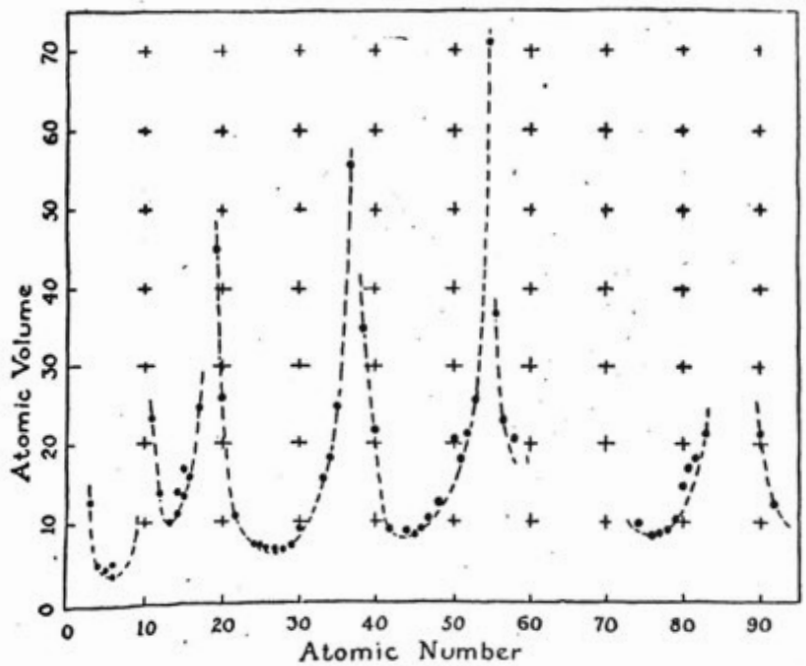



FIG. 5-1. Curve of atomic volume (volume containing 1 gram-atom) of elements as function of atomic number, illustrating periodicity of properties.

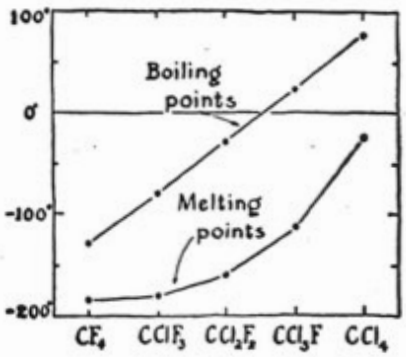



FIG. 15-5. The effect of molecular symmetry on melting point.

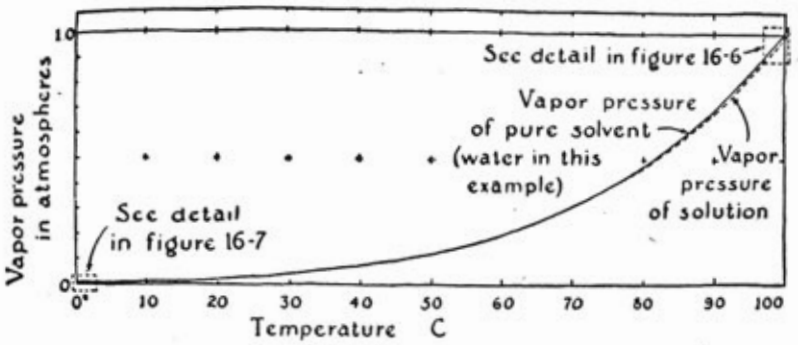



FIG. 16-5. Vapor pressure curve of water in the range 0° to 100° C.

All from Linus Pauling. General Chemistry

vapor pressure) between the two liquids water enters the cell. If the cell wall were sufficiently strong, equilibrium would be reached when the hydrostatic pressure in the cell had reached a certain value, at which the water vapor pressure of the solution equals the vapor pressure of the pure water outside the cell. This equilibrium hydrostatic pressure is called the *osmotic pressure* of the solution.

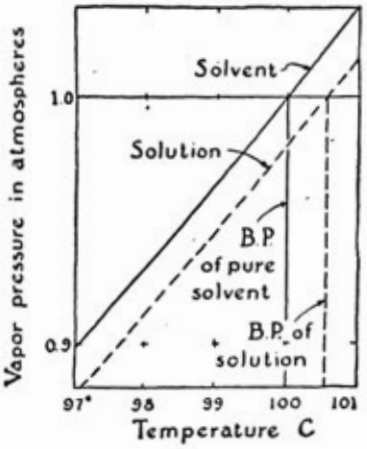



FIG. 16-6. Vapor pressure curves of water and an aqueous solution near the boiling point, showing elevation of boiling point of the solution.

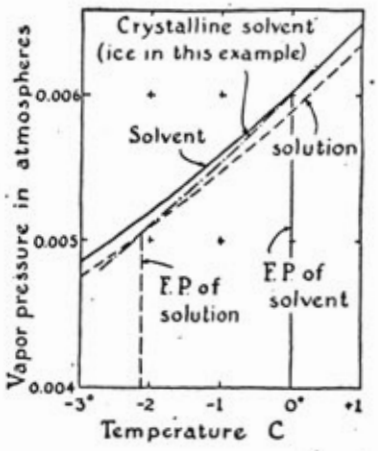



FIG. 16-7. Vapor pressure curves of water, ice, and an aqueous solution near the freezing point, showing depression of freezing point of the solution.

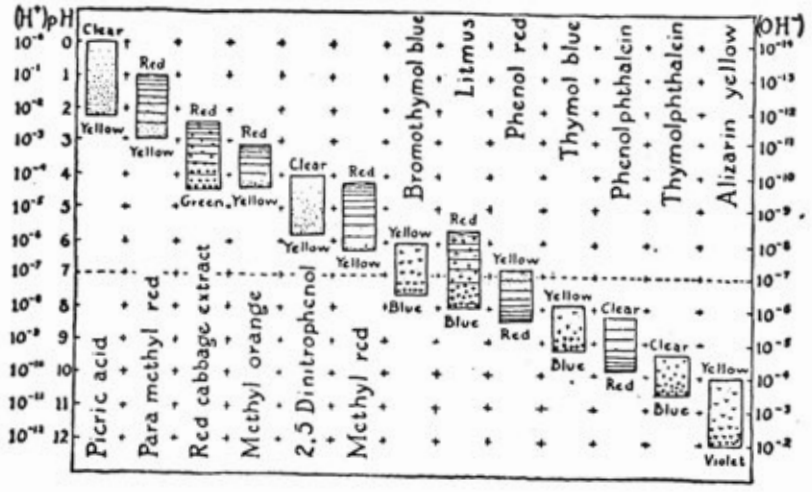



FIG. 21-1. Color changes of indicators.

(1)

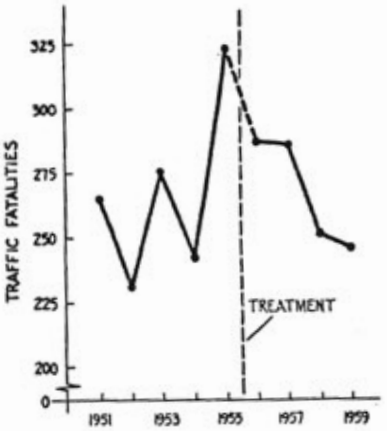
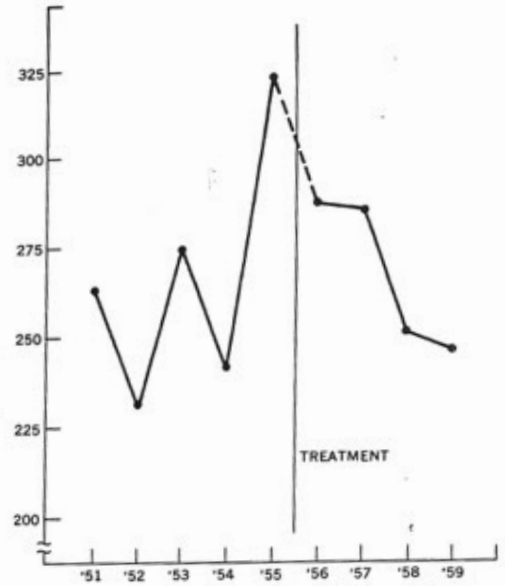



FIGURE 2
*Connecticut traffic fatalities, 1951–59. Source: Campbell and Ross (1968)*

(2)




**2** Connecticut traffic fatalities, 1951–1959.

(3)

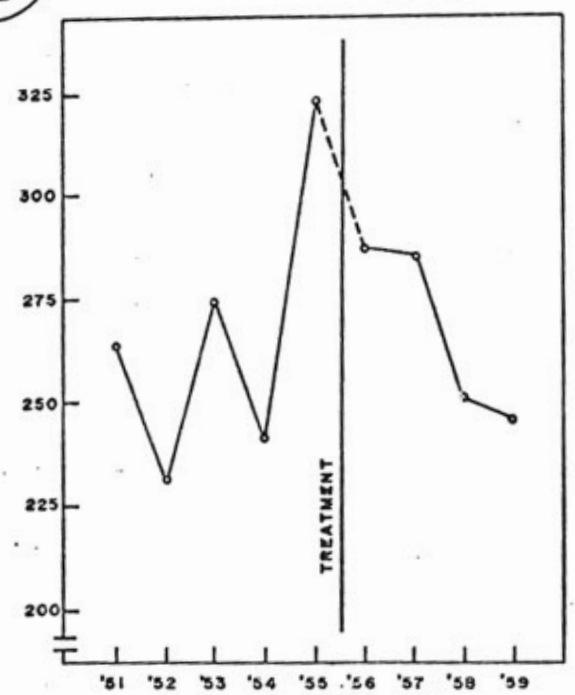



FIG. 2. Connecticut traffic fatalities. (Same data as in Figure 1 presented as part of an extended time series.)

Sources:

1. Donald T. Campbell, "Measuring the Effects of Social Innovations by Means of Time Series," in Statistics: A Guide to the Unknown, eds. Judith M. Tanur, et al. (San Francisco: Holden Day, 1972), p. 122.

2. Donald T. Campbell and Laurence Ross, "The Connecticut Crackdown on Speeding: Time-Series Data in Quasi-Experimental Analysis," in The Quantitative Analysis of Social Problems, ed. Edward R. Tufte (Reading, Massachusetts: Addison-Wesley, 1970), p. 115.

3. Donald T. Campbell, "Reforms as Experiments," American Psychologist, 24 (April, 1969), p. 413.

The next three pages show parallel plots in graphs--usually time series marching along together. Parallel series are often an effective form of presentation, although sometimes a scatterplot would be more revealing.

Consistently high quality parallel plots of economic series are found in Business Week. Good parallel plots are also found in the Department of Commerce publication Business Conditions Digest.

**Correction**

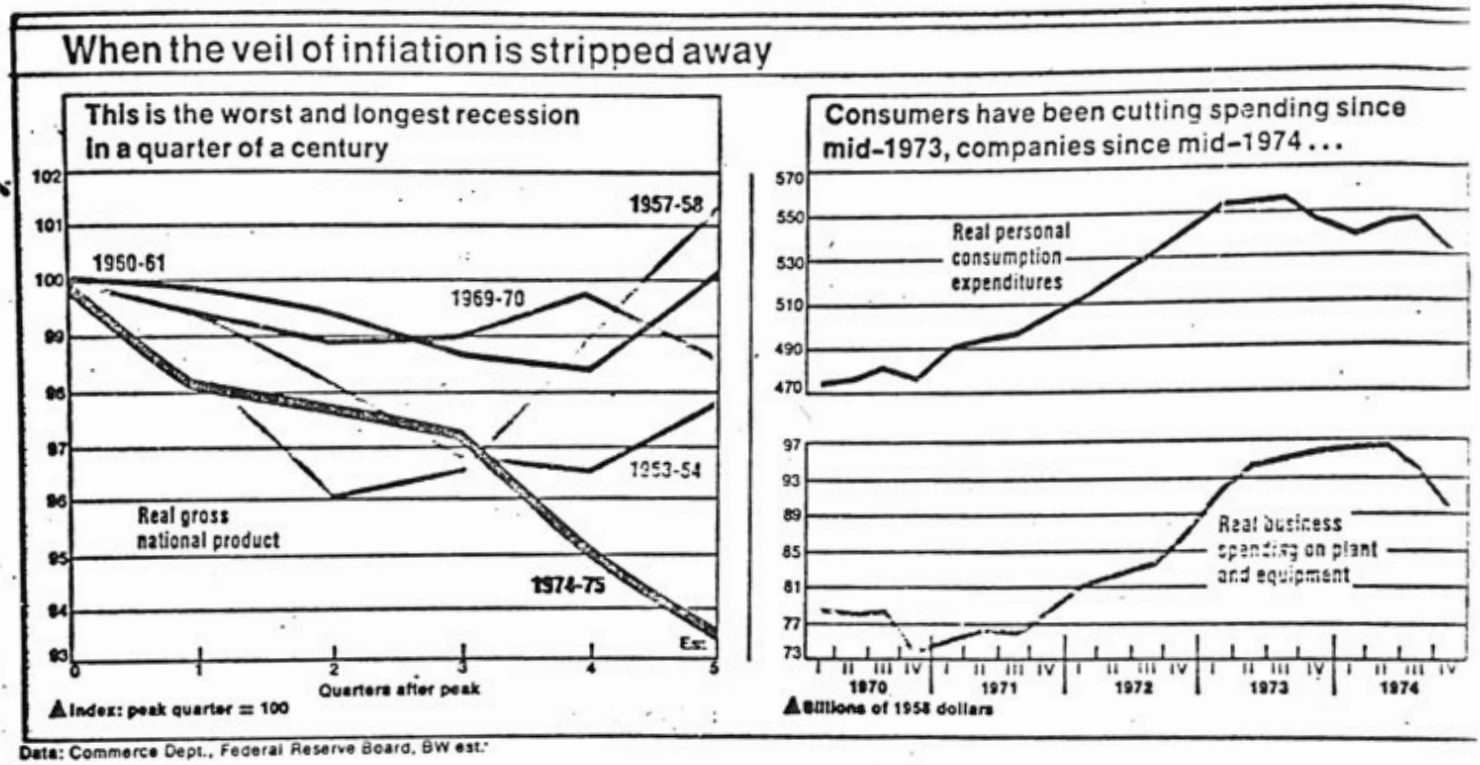
*In last week's Review, a drawing of the finback whale appeared this way:*

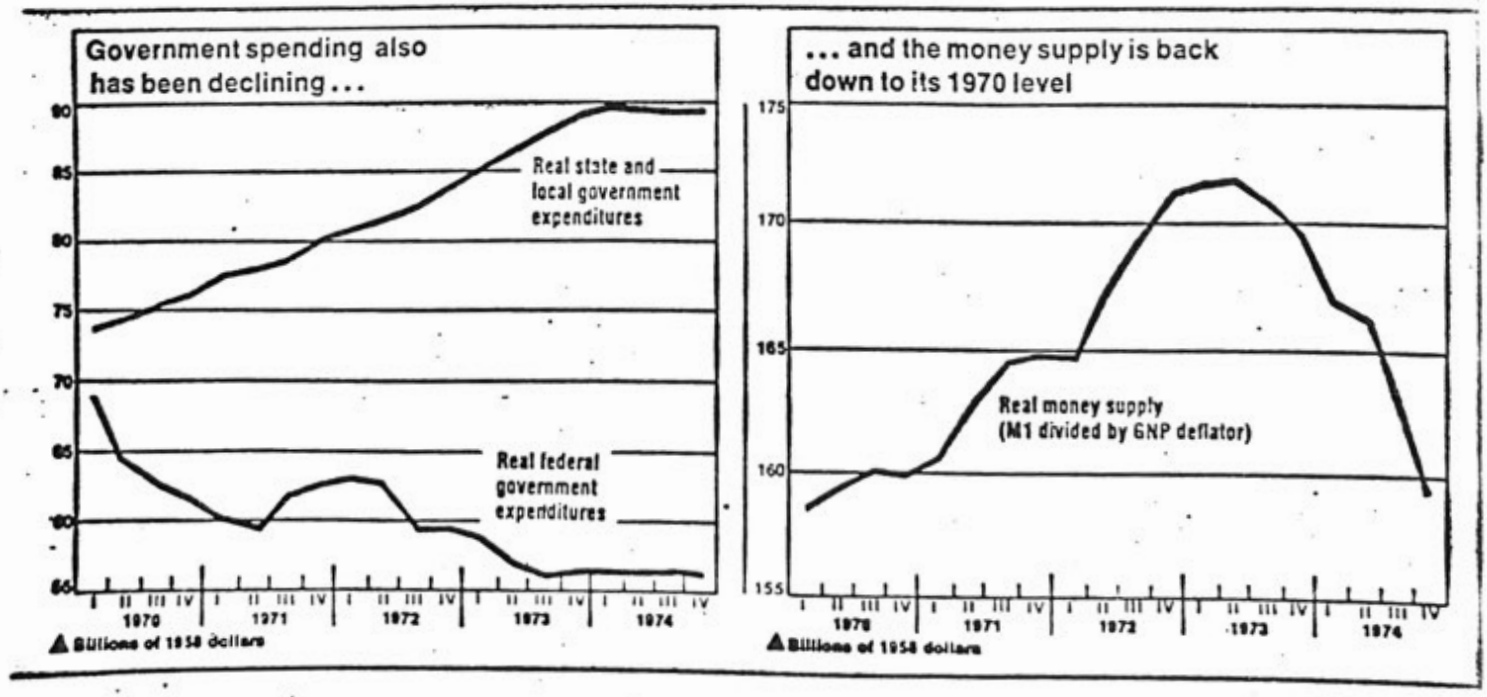
*The drawing should have appeared this way:*

*The Review regrets the error. Whales, however, do spend just about as much of their time swimming on their backs as they do right side up.*

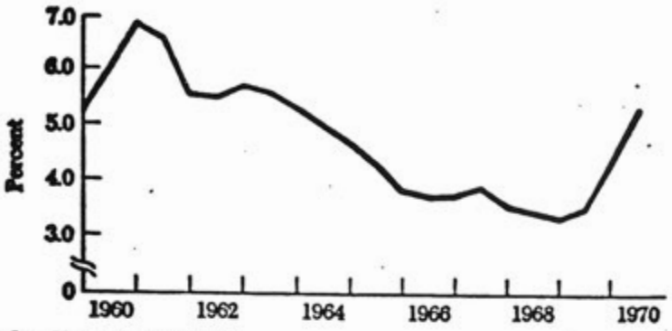
New York Times, July 6, 1975.

Here are some parallel parallel plots. I like the way they put a complex set of data together. This is a very attractive presentation (particularly in the original, which was in color), although some of the verbal descriptions are not perfectly precise and "stripping away the veil of inflation" is not the freshest phrase. In general, however, I like the idea of having a short sentence describing the main thrust of the graph, giving readers a quick summary and leading them naturally to the detail of the graph itself. These graphs are from Business Week (February 3, 1975; 67-68)--a magazine which has pretty good graphic displays, usually of the kind we see here.



Consider:




(b) Unemployment rate


(c) Rate of inflation

Source: William H. Branson, Macroeconomic Theory and Policy (New York: Harper and Row, 1972), p. 6.

This parallel plot tries to serve too many purposes. The extensive text accompanying the plot deals with (1) the ups and downs of the U.S. economy from 1960 to 1971 and (2) the relationship, when and if there is one, between the inflation rate and the unemployment rate. Point (2) is discussed as follows:

> **Figure 1-1**(b) plots the unemployment rate corresponding to the gap in Figure 1-1(a). In general, the larger the GNP gap, the greater the unemployment rate. Figure 1-1(c) shows the percentage (annual) rate of change of the CPI—the rate of inflation—corresponding to the GNP gap and unemployment-rate series. Comparison of Figures 1-1(b) and 1-1(c) shows that, in general, as the unemployment rate has been reduced, the rate of inflation has risen. This is the *Phillips curve* relationship between unemployment and the rate of inflation that is discussed in Chapter 16. It is also interesting to notice that from 1961 to early 1965, as the unemployment rate gradually came down, there was no perceptible increase in the rate of inflation. But the further drop in unemployment from early 1965 to 1966 brought a sharp increase in the rate of inflation, and the maintenance of a level of demand pressure that kept unemployment below 4 percent from 1966 through 1969 generated a continuing inflation that only showed faint signs of slowing by mid-1970.

Now for point (2), we would really like to see a scatterplot of the inflation rate plotted against the unemployment rate. Or perhaps their quarterly first differences.

One version of the desrived plot is shown on the next page. It is revealing.

Phillips Curve

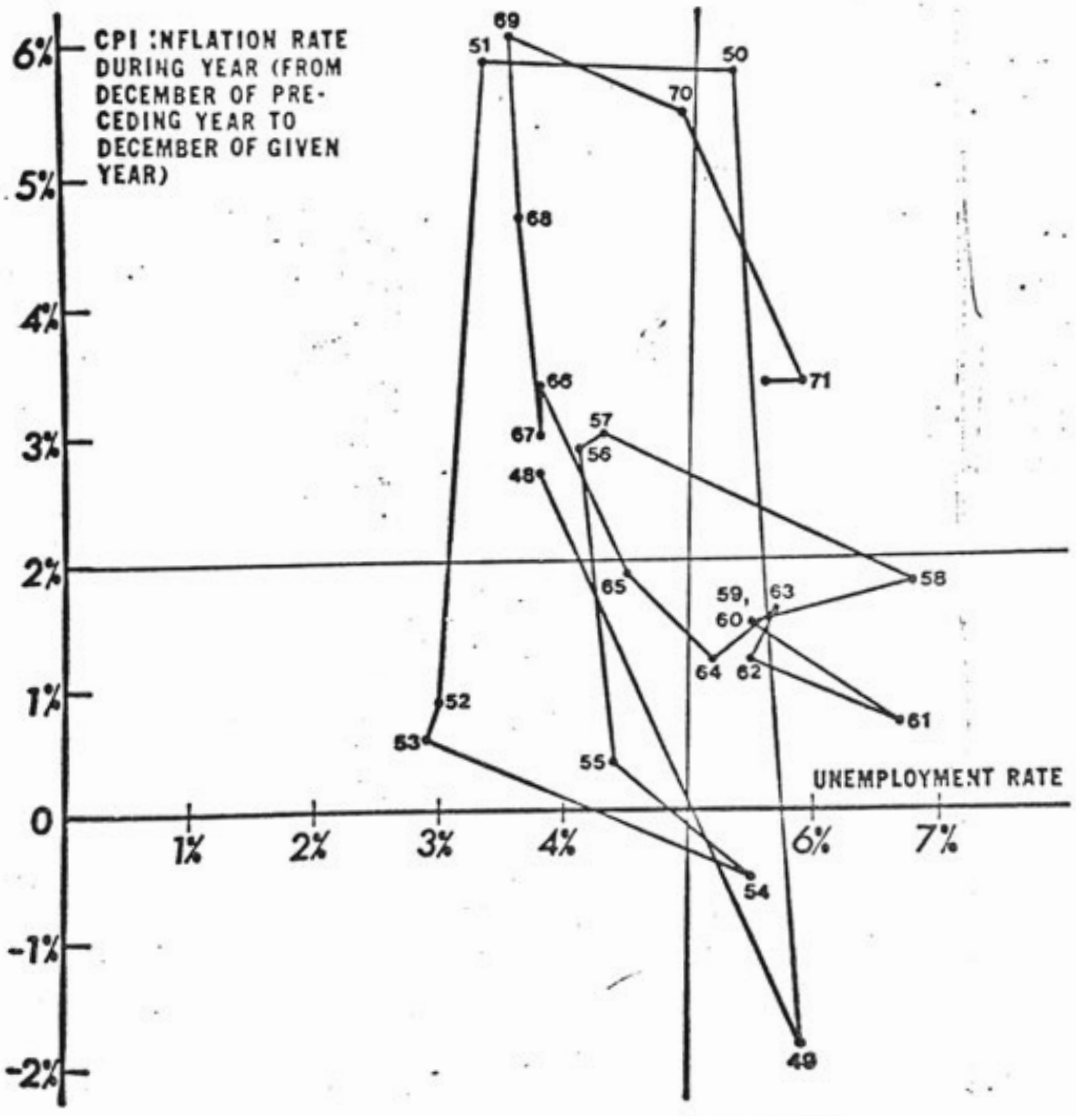
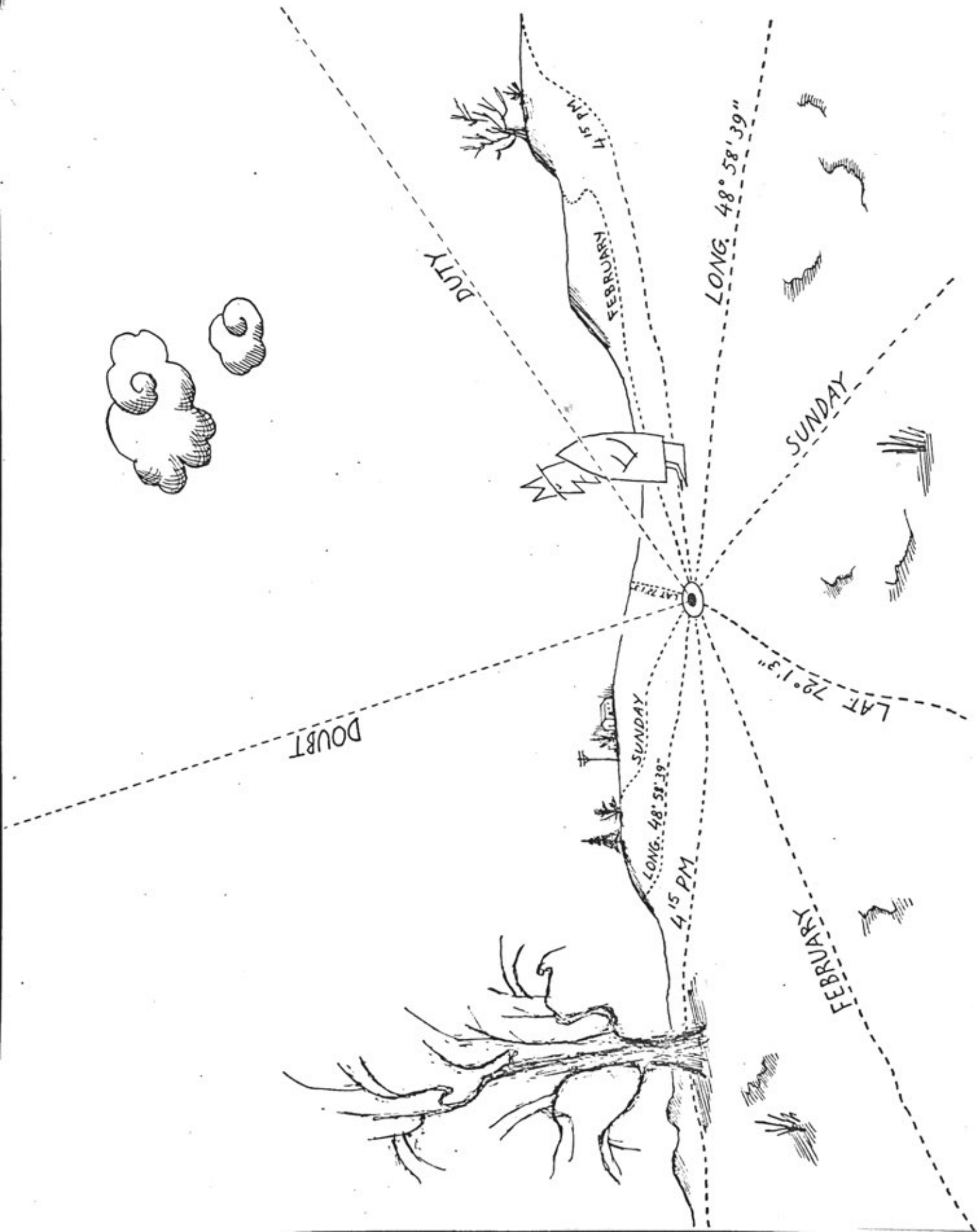



FIGURE 1. INFLATION RATE VS. UNEMPLOYMENT RATE, 1948-72

Source: Carl F. Christ, "The 1973 Report of the President's Council of Economic Advisers: A Review," American Economic Review, 63 (September, 1973), p. 517.


DUTY
4:15 PM
FEBRUARY
LONG. 48° 58' 39"
SUNDAY
LAT. 78° 13"
DOUBT
SUNDAY
LONG. 48° 58' 39"
4:15 PM
FEBRUARY

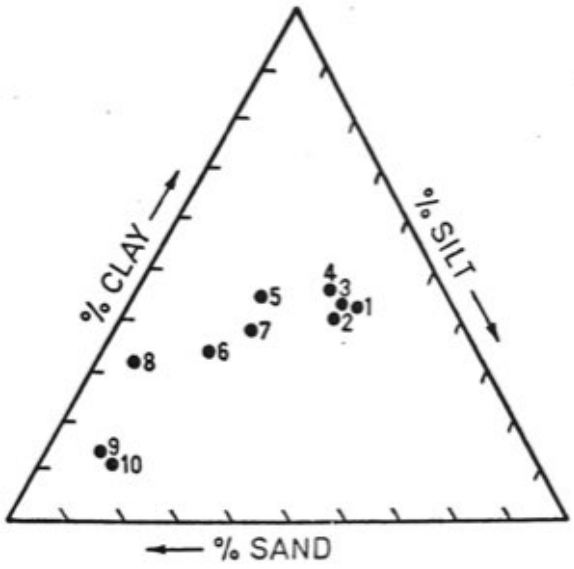
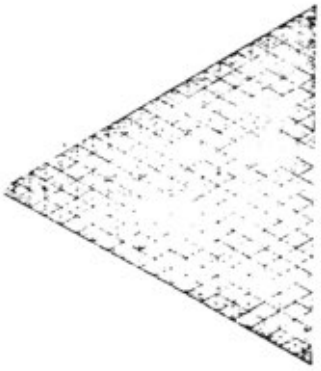



FIG. 5. Soil texture of *A* horizon under mixed grassland communities in western North Dakota. Numbers refer to stands described in text.

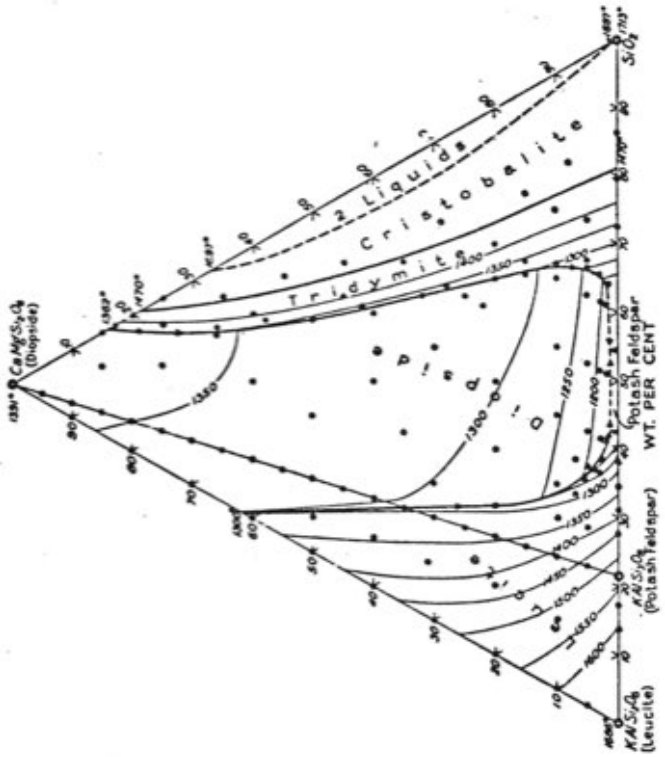
Source: Robert E. Redmann, "Production Ecology of Grassland Plant Communities in Western North Dakota," Ecological Monographs, 45 (Winter, 1975), p. 93.



Kruffel & Esser Co., N. Y.

**A. Triangular Coordinate Graph Paper.**

The trilinear chart was first used for investigation on strength of concrete mixtures. This form lends itself to the demonstration of problems involving a mixture of three ingredients, such as alloys containing three metals and food rations containing three dietetic elements.




J. F. Schairer and N. L. Bowen, "The System, Leucite—Diopside—Silica," American Journal of Science, 1938. Geophysical Laboratory, Carnegie Institution of Washington.

**B. Equilibrium Diagram of the Ternary System, Leucite—Diopside—Silica.**

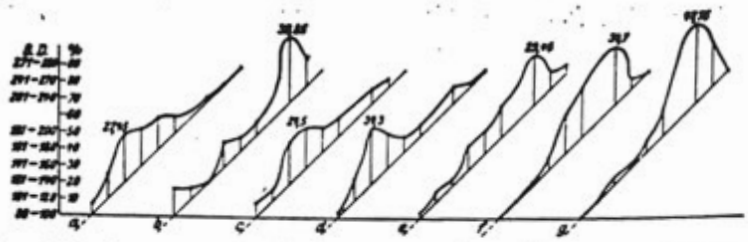


FIG. 20.2. Frequency distribution curves of systolic pressure (B.D.) in different forms of nephritis and sclerosis: *a* = acute; *b* = subacute; *c* = subchronic; *d* = chronic; *e* = secondary contracted kidney; *f* = essential hypertension and benign sclerosis; *g* = malignant sclerosis (Volhard (1931), *Handbuch der inneren Medizin*. Berlin: Springer. Fig. 299).

Source: George Pickering, High Blood Pressure (London: J. & A. Churchill, 1968), p. 445.

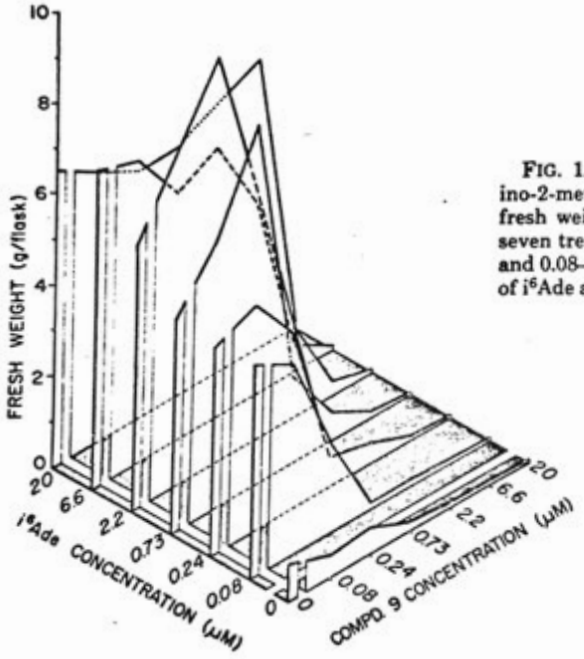



FIG. 1. The effects of serial combinations of 4-cyclohexylamino-2-methylthiopyrrolo[2,3-*d*]pyrimidine (9) and i⁶Ade on the fresh weight yield of tobacco callus. Bud formation occurred in seven treatments as follows: the five treatments with 20 μM i⁶Ade and 0.08–6.6 μM 9, and two treatments with 2.2 μM or 6.6 μM each of i⁶Ade and 9. Test period: 6 Dec. 1974 to 10 Jan. 1975.

Source: Folke Skoog, Ruth Y. Schmitz, et al., "Anticytokinin Activity of Substituted Pyrrolo(2,3-d) Pyrimidines," Proc. Nat. Acad.USA, 72 (1975), p. 3510.

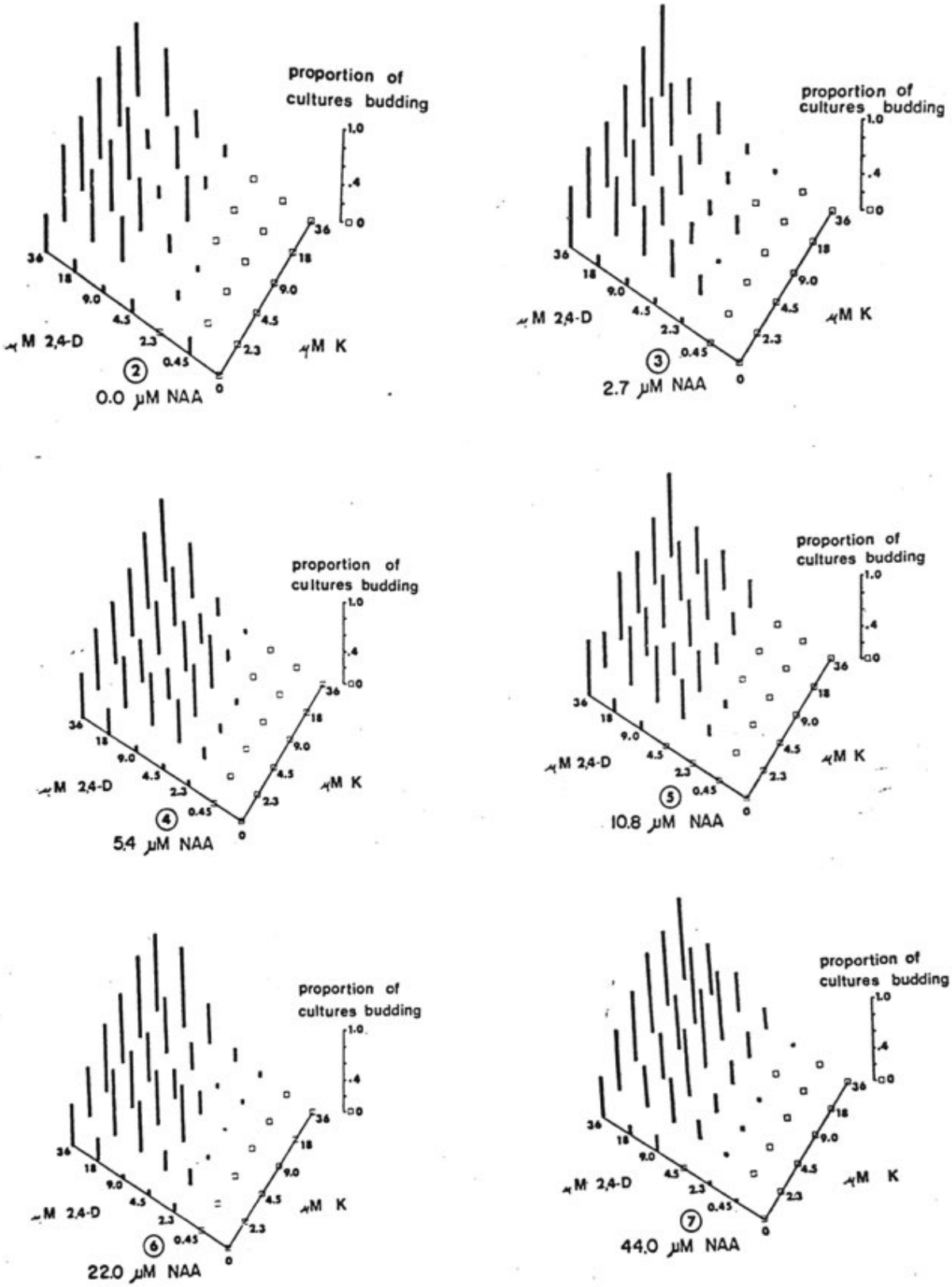



Fig. 2-7. Effects of combinations of 2,4-D and kinetin on bud formation, in the presence of 0.0, 2.7, 5.4, 10.8, 22.0, and 44.0 μM NAA. 2. 0.0 μM. 3. 2.7 μM. 4. 5.4 μM. 5. 10.8 μM. 6. 22.0 μM. 7. 44.0 μM.

Source: J. W. Saunders and E. T. Bingham, "Growth Regulator Effects on Bud Initiation in Callus Cultures of Medicago Sativa, " American Journal of Botany, 62 (September, 1975), p. 852.

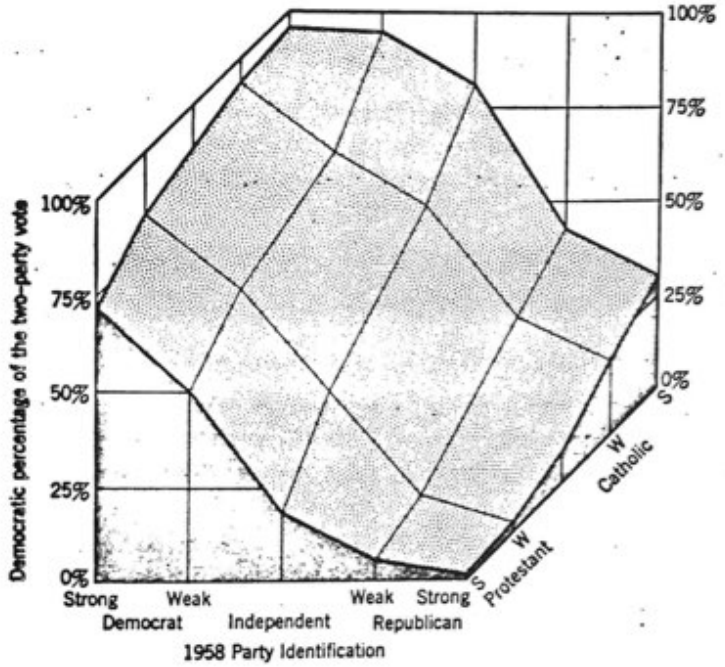



**Figure 6-2a.** 1960 presidential vote by party identification (1958) and by religious identification (1960).

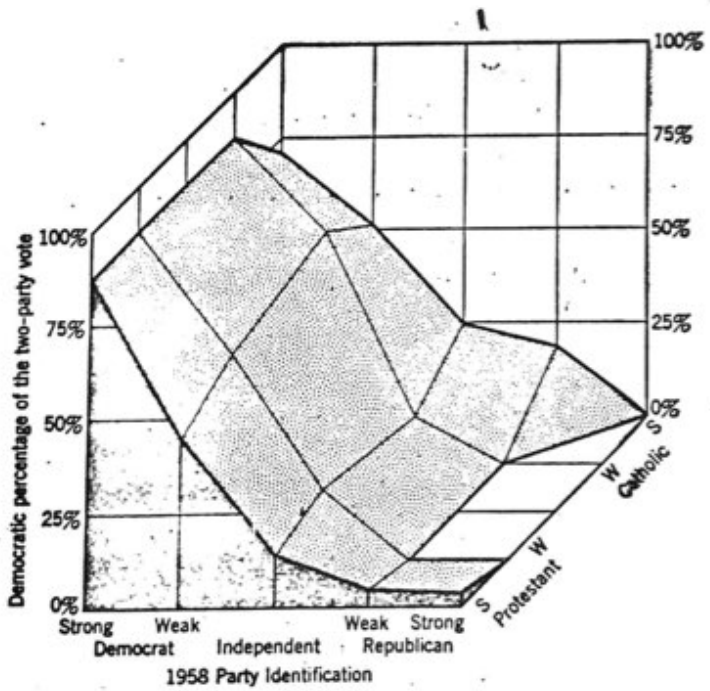



**Figure 6-2b.** 1956 presidential vote by party identification (1958) and by religious identification (1960).

Source: Philip E. Converse, "Religion and Politics: The 1960 Election," in Angus Campbell, Philip E. Converse, Warren E. Miller, and Donald E. Stokes, Elections and the Political Order (New York: Wiley, 1966), pp. 102-103.


"*For a little extra we could have got Giotto.*"

New Yorker p.40
late 75 or early 76

OPTICAL ART EFFECTS

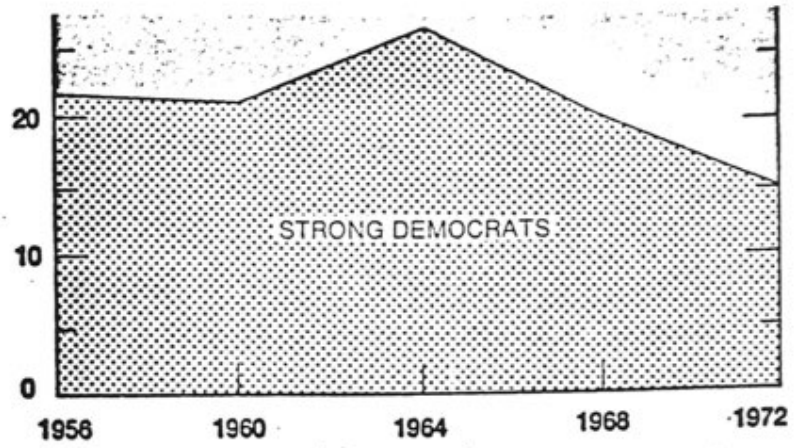
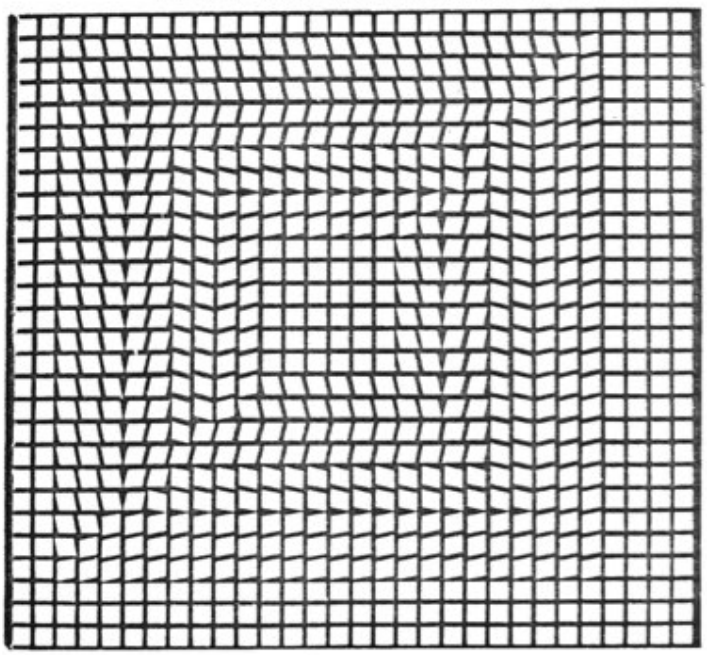


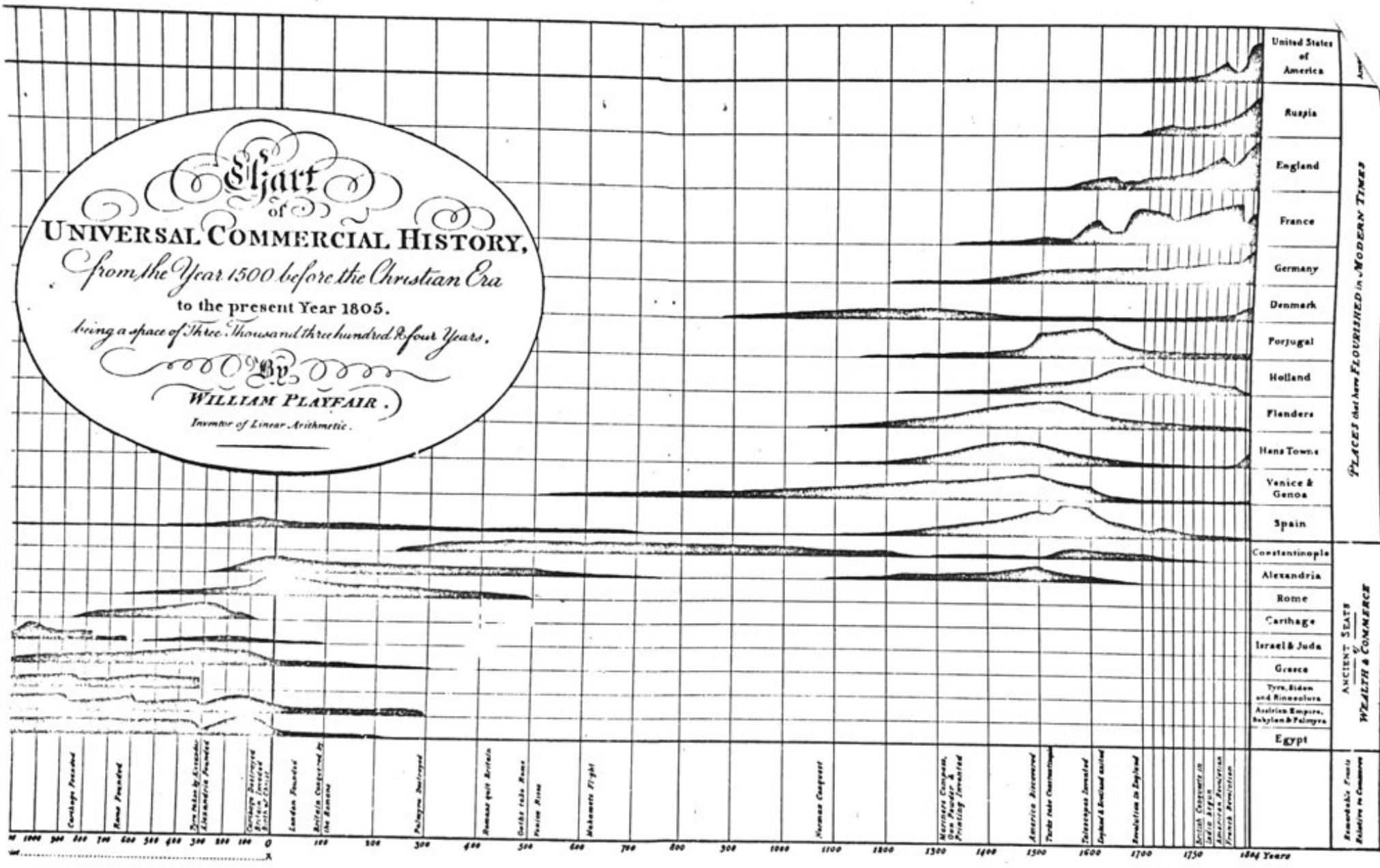

**FIGURE 2.1 / PARTISAN LOYALTY FROM 1956 TO 1972**

**Source:** Gerald Pomper, Voters' Choice: Varieties of American Electoral Behavior (New York: Dodd, Mead, 1975), p. 21.

7. Victor Vasarely, *Tau-Ceti*, 1955–65. Coll. the artist.



Source: George Rickey, Constructivism: Origin and Evolution (London: Studio Vista, 1968), p. 183.

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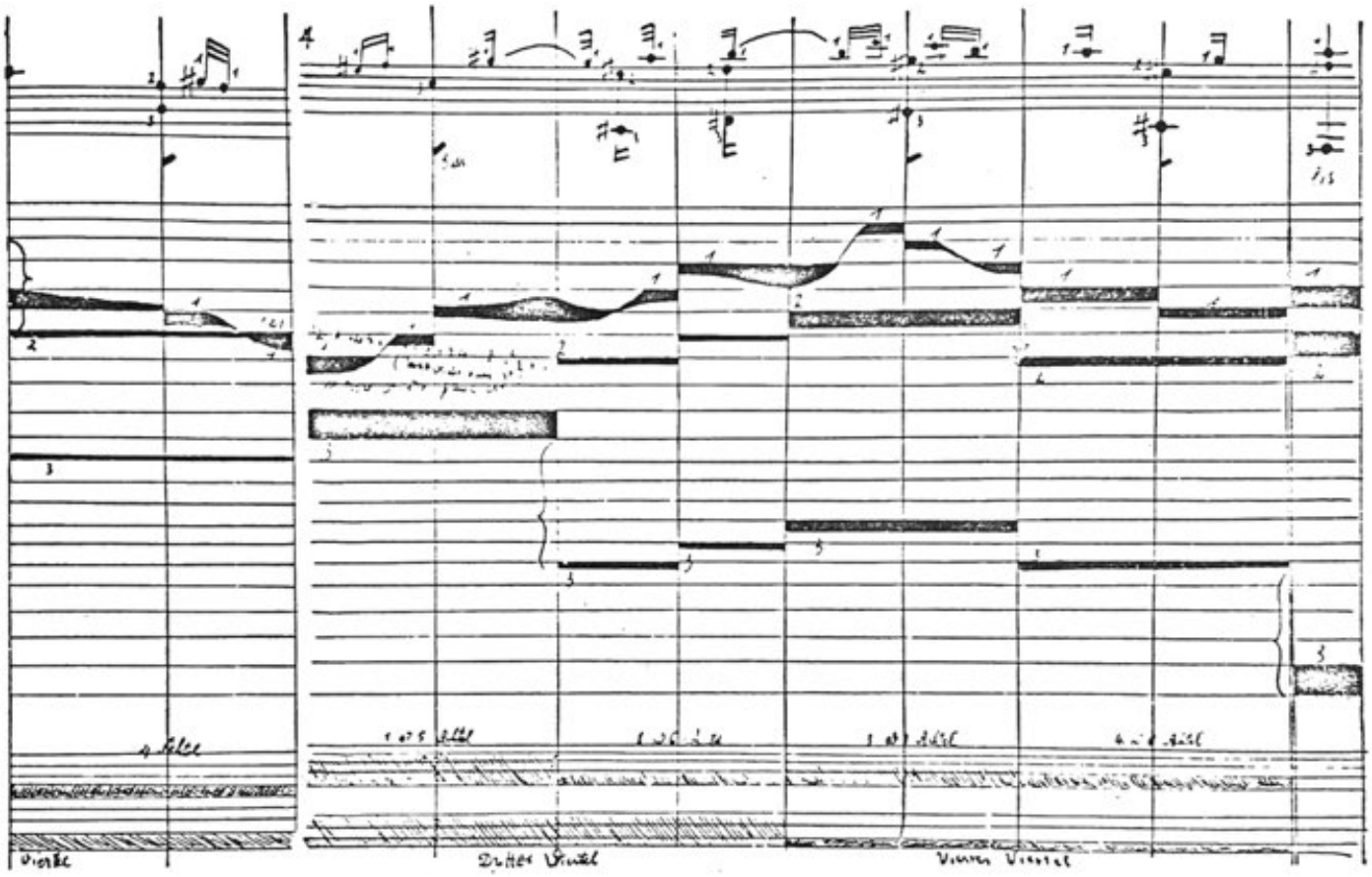
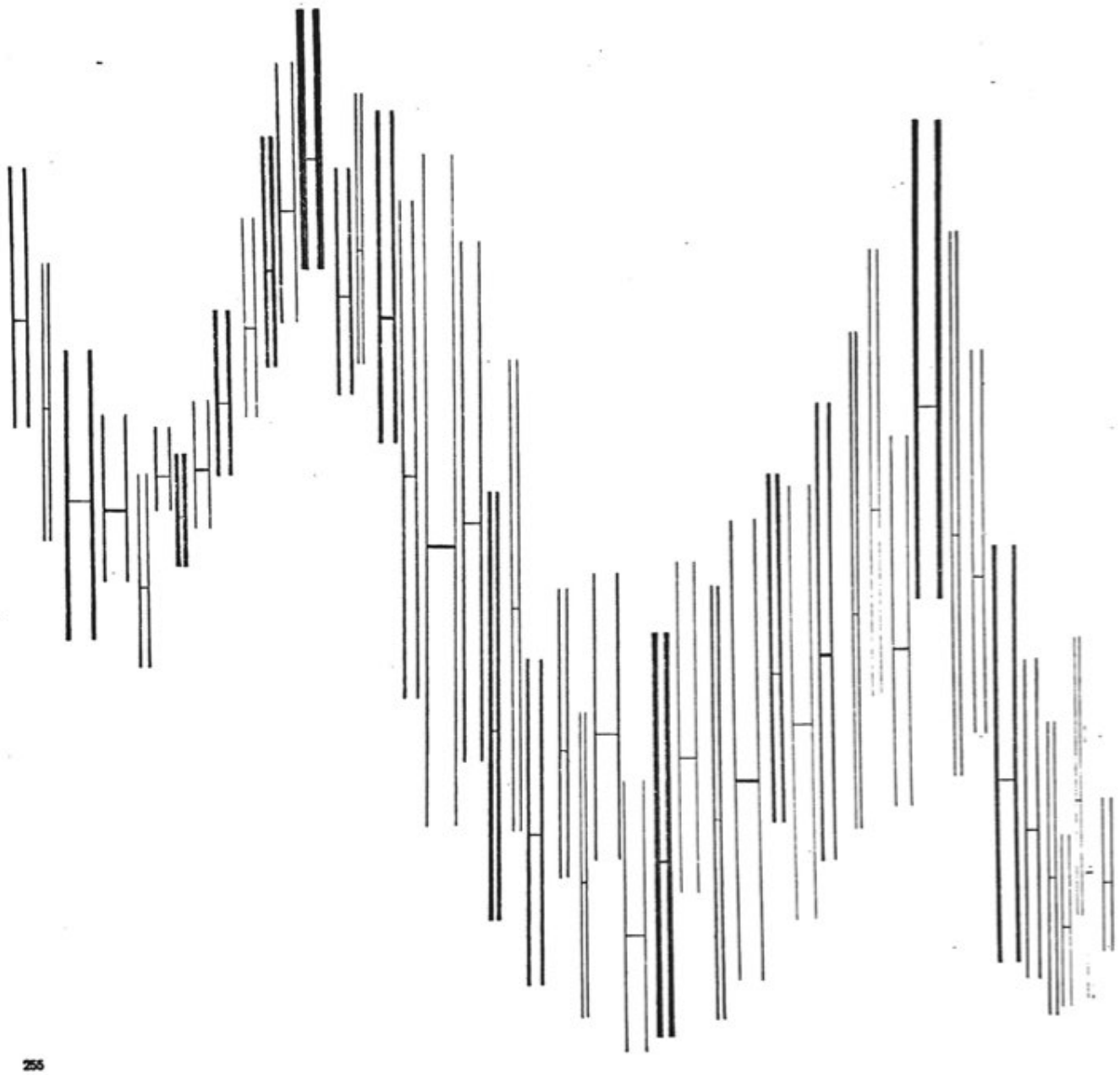
*From Frontispiece of Book by* WILLIAM PLAYFAIR, An Inquiry Into the Permanent Causes of the Decline and Fall of Powerful and Wealthy Nations, London 1805



**Pictorial example after a three-part movement by J. S. Bach** (see pp. 285–287).

Source: Paul Klee, Notebooks, Volume 1, The Thinking Eye (London: Lund Humphries, 1961), insert at pp. 286-287.




Source: Armin Hofmann, Graphic Design Manual: Principles and Practice (New York: Van Nostrand, 1965), p. 149.

TOO MANY COMMENTS ON A SCATTERPLOT

The scatterplot below appeared in Bruce Bueno de Mesquita, "Need for Achievement and Competitiveness as Determinants of Political Party Success in Elections and Coalitions," American Political Science Review, 68 (September, 1974), p. 1220.

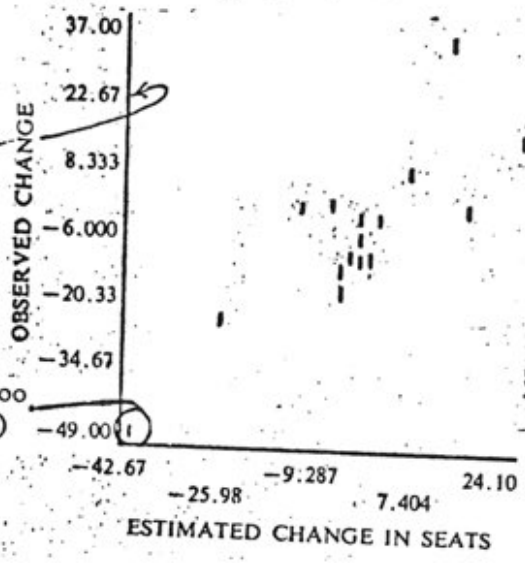



Figure 1. Scatterplot of the Observed Change in Vidhan Sabha Seats Won by 16 Parties Between 1967 and 1969 Compared to the Estimated Change in Their Representation As a Function of Their Legislative Strength in 1967, Their Strategic Predispositions, and Their Need for Achievement.

no interval marks on axes

note outlier (axes are too close to this data point)

up and down placement of numbers would be avoided if unit measure used

The following things are wrong with this data display:

1. The X and Y scales are fruity. Why are the intervals taken at such points as -9.287, 7.404, and all the rest? Why is the scale interval 14.33 (sometimes 14.34) units? Since the units actually measured are legislative seats, it would be better to have simple round numbers as the interval markers. Why are the scale intervals on the X-axis different than on the Y-axis?

2. Four significant digits are presented. This is pseudo-accuracy--just because the computer printed all those significant digits, it doesn't mean that they are significant. What does a change of -9.287 seats mean?

3. Why are the data points indicated by those asymmetric marks? Why not use dots?

4. Since this is a display of observed values vs. predicted values, there is a natural reference point: a 45-degree line. On such a line, observed values equal predicted values. Also both the X and Y axes should start at the same point in this case--since we are comparing predicted vs. observed values.

5. The caption on the graph is hopelessly complicated.

6. The graph is designed to illustrate the relationship between observed and predicted values, a relationship already described in the text and the tables of the paper. To show that this is a visual display of a previous quantitative message, the graph might have "$R^2 = .72$" on it, somewhere in all that empty space.

7. Overall, the graph has an amateurish look to it.

Attached are two examples, both prepared professionally, of graphs displaying an observed-predicted relationship in a superior way.

E. R. Tufte
January 3, 1976

New York Times, January 3, 1975

Path of temperature variation in relation to normal high and low is good. Attracts reader's eye to the data, to the detail of the data.

No accompanying text provided. Would be very helpful.

Graph in upper left is not much good. One very brief sentence would capture same information--if it has any meaning at all. Average annual temperature?

Rain chart might be expressed as a day's rain ala the stock market volume. Or maybe cumulate to the end of the month, so that heavy rains would be linked to time of month. At any rate, big, heavy bars aren't needed here. One possibility is to cumulate and then also show, with a tic, the normal. Note that the normal is not very interesting on this scale because it displays little variation. There is something of interest in the path of the normal (several cycles) but it is not captured well at all.

I get nothing out of the bottom chart showing the daily path of the relative humidity at noon. It just encourages some spurious cycle hunting, I suspect.

Since the graph is published in January, the January beginning is all right--letting us see what is ahead.

It is interesting to think about the meaning of the black space in the temperature path.

What would be the normal high and low and also average of temperature path.

What would be the normal high and low and also average of temperature of air people are exposed to?

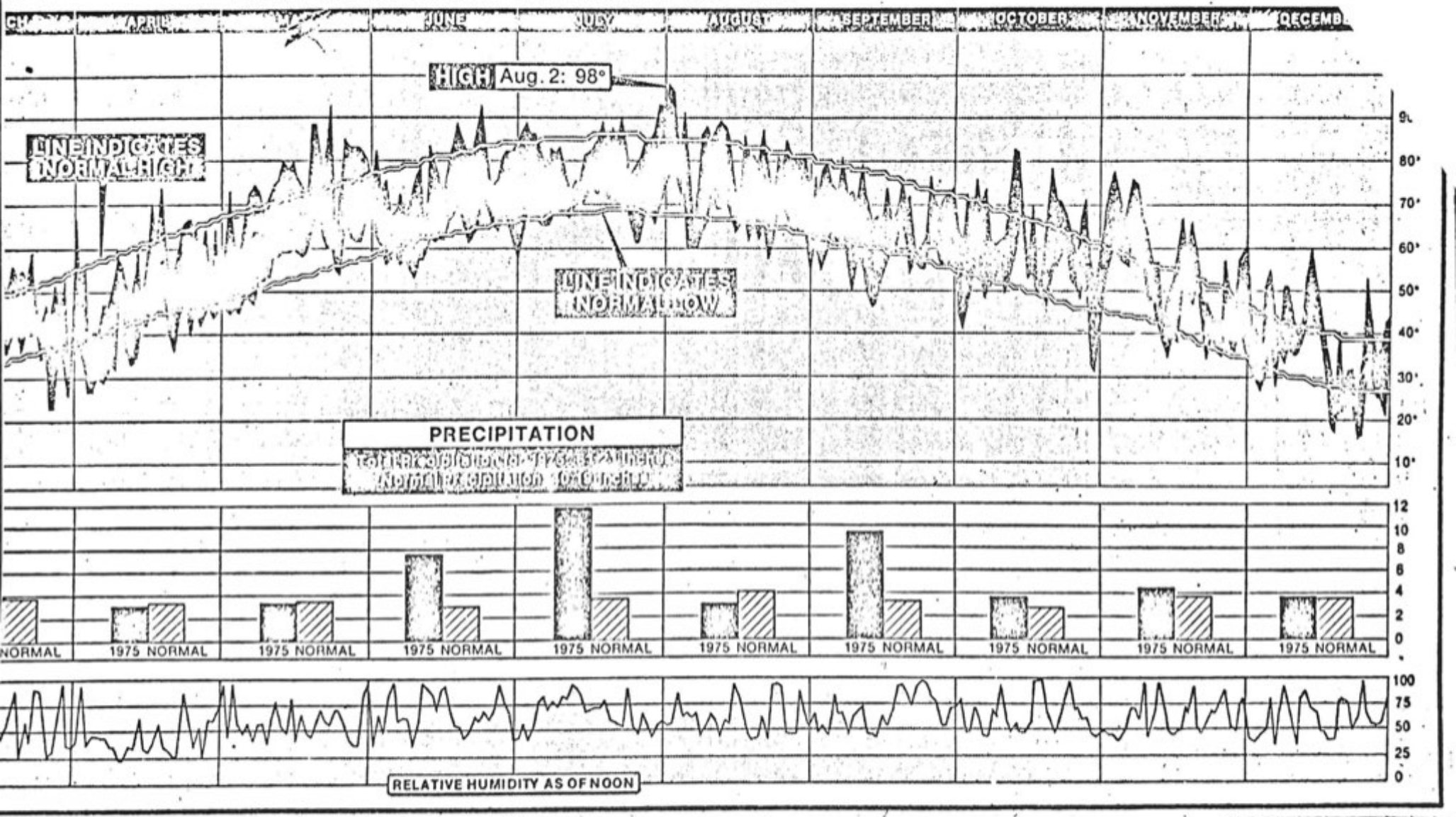
Main improvements:

(1) drop annual temperature comparison in upper right
(2) plot rain by day just like stock market volumes (or relative humidity)
(3) drop relative humidity
(4) think of other data to replace items dropped.

This is one of the most interesting graphs published in the Times.

Times

# NEW YORK CITY'S WEATHER FOR 1975



January 3, 1976 New York Times

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