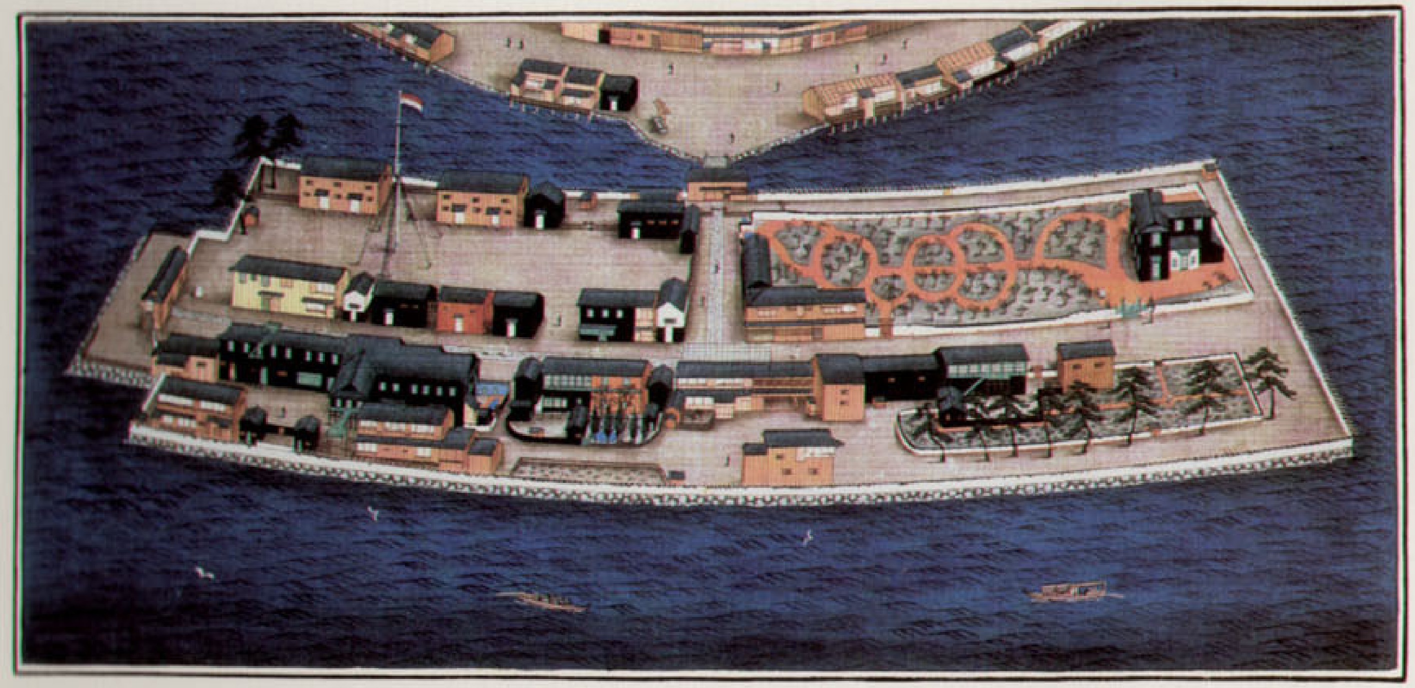
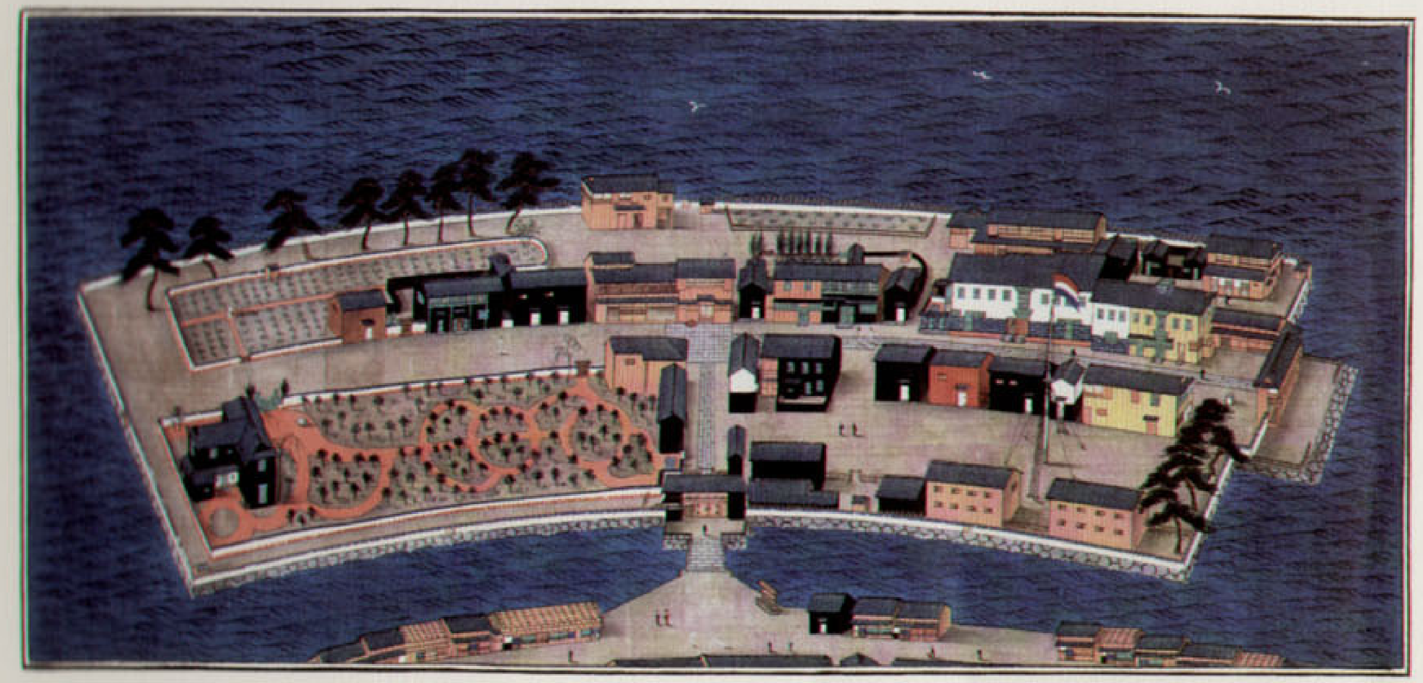


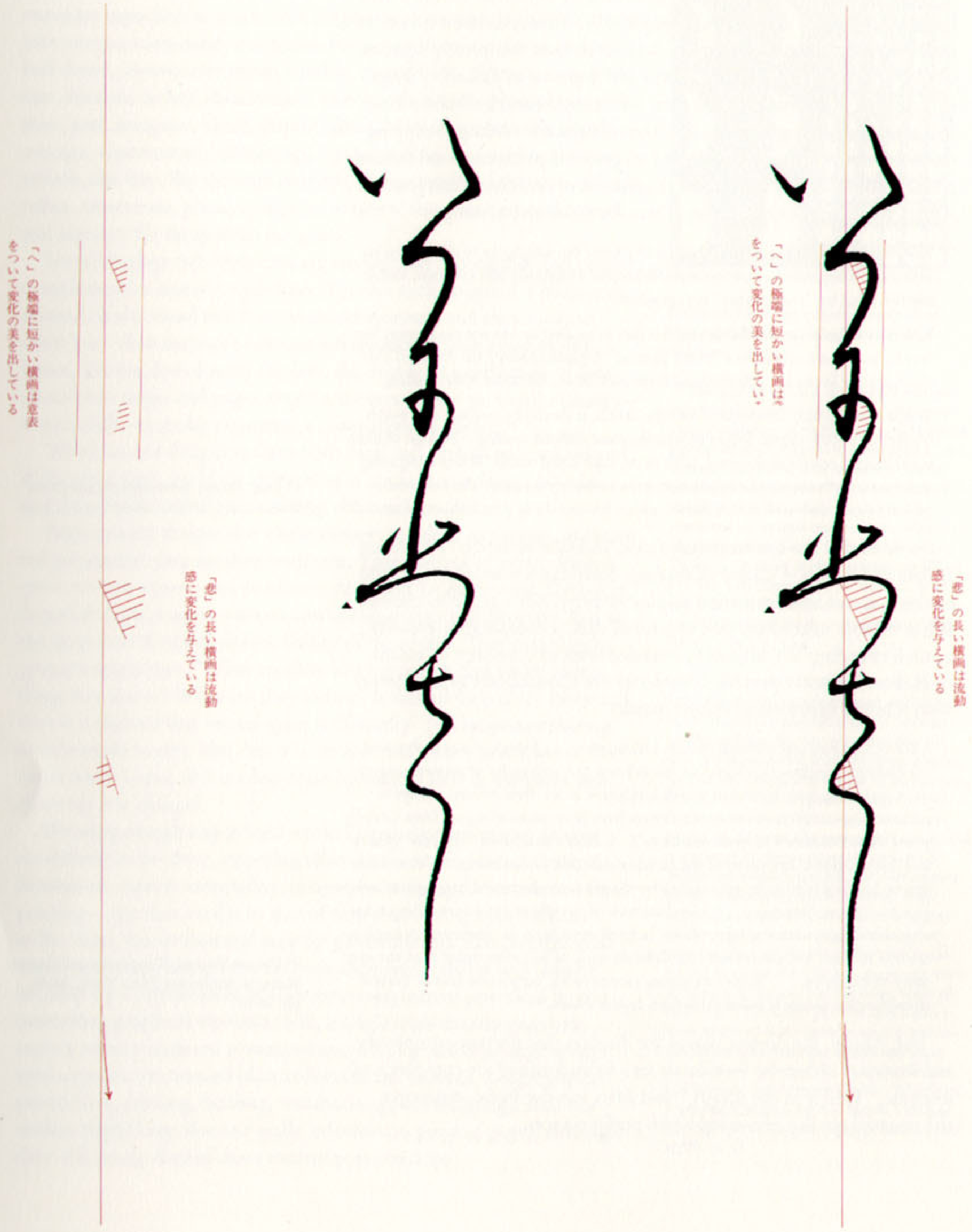


Two paintings on silk depicting Deshima Island, a view from the Bay (top), a view from Nagasaki (bottom), circa 1860.

Edward R. Tufte

Envisioning Information

Graphics Press · Cheshire, Connecticut


「へ」の極端に短かい横画は意表をついて変化の美を出している
「悲」の長い横画は流動感に変化を与えている
「へ」の極端に短かい横画は
をついて変化の美を出してい
「悲」の長い横画は流動感に変化を与えている

Uboku Nishitani, *Koyagire Daiishu* [*The First Seed of Koyagiri*], volume 17 of *Shodo Giho Koza* [*Techniques in Calligraphy*] (Tokyo, 1972), p. 56. Redrawn.

3 *Layering and Separation*

CONFUSION and clutter are failures of design, not attributes of information. And so the point is to find design strategies that reveal detail and complexity—rather than to fault the data for an excess of complication. Or, worse, to fault viewers for a lack of understanding. Among the most powerful devices for reducing noise and enriching the content of displays is the technique of layering and separation, visually stratifying various aspects of the data.

Effective layering of information is often difficult; for every excellent performance, a hundred clunky spectacles arise. An omnipresent, yet subtle, design issue is involved: the various elements collected together on flatland *interact*, creating non-information patterns and texture simply through their combined presence. Josef Albers described this visual effect as *1 + 1 = 3 or more*, when two elements show themselves along with assorted incidental by-products of their partnership—occasionally a basis for pleasing aesthetic effects but always a continuing danger to data exhibits.[1] Such patterns become dynamically obtrusive when our displays leave the relative constancy of paper and move to the changing video flatland of computer terminals. There, all sorts of unplanned and lushly cluttered interacting combinations turn up, with changing layers of information arrayed in miscellaneous windows surrounded by a frame of system commands and other computer administrative debris.

AT left a second color annotates the brush strokes of the calligrapher, Uboku Nishitani. By creating a distinct layer, the red commentary maintains detail, coherence, and serenity, in a crisp precision side-by-side with a gestural and expressive black line in this marriage of color and information. The saturated quality of the red partially offsets its lighter value and finer line (appropriate to meticulous annotation). Alone, each color makes a strong statement; together, a stronger one.

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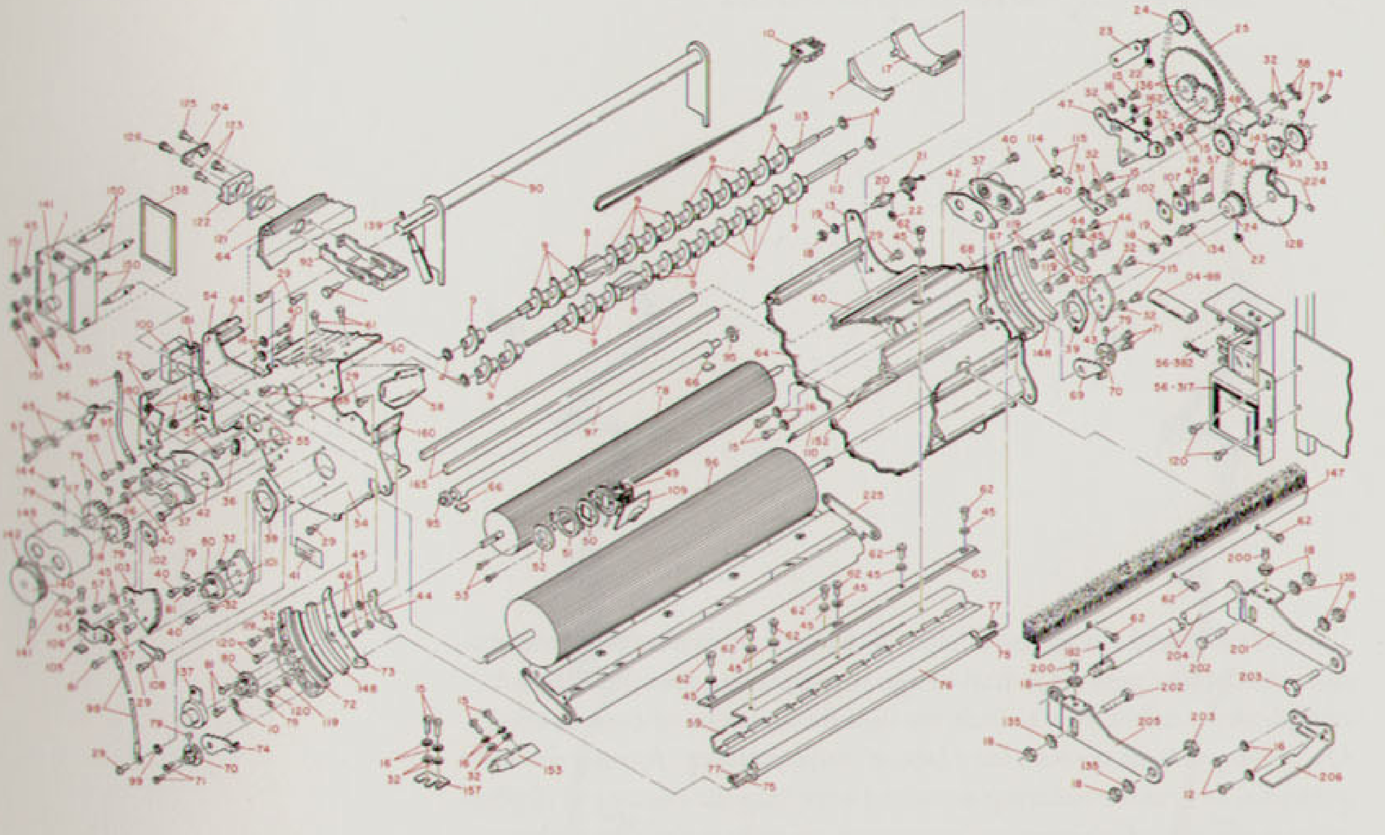
[1] Josef Albers, "One Plus One Equals Three or More: Factual Facts and Actual Facts," in Albers, *Search Versus Re-Search* (Hartford, 1969), pp. 17–18.

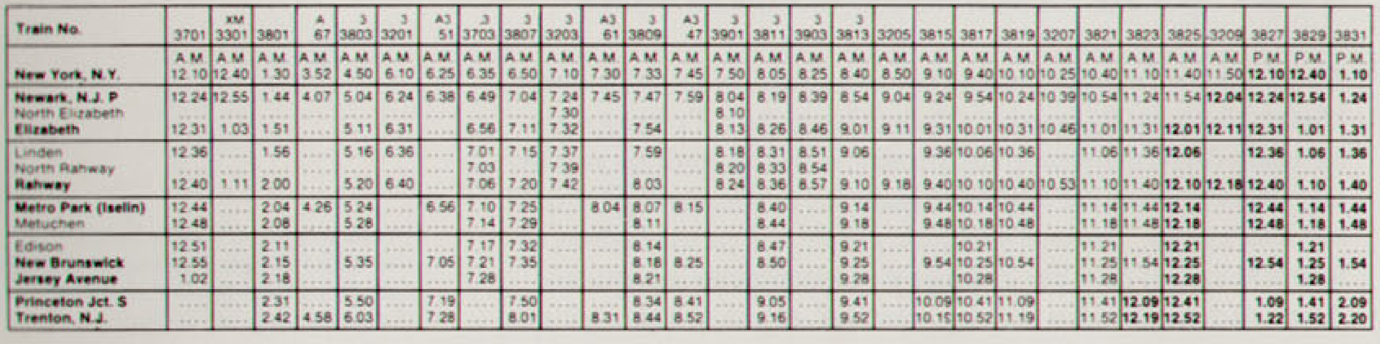


Similarly, color effortlessly differentiates between annotation and annotated, in this skillful industrial-strength diagram separating 300 small parts and their identifying numbers.

IBM Series III Copier/Duplicator, Adjustment Parts Manual (Boulder, Colorado, 1976), p. 101. Drawn by Gary E. Graham.

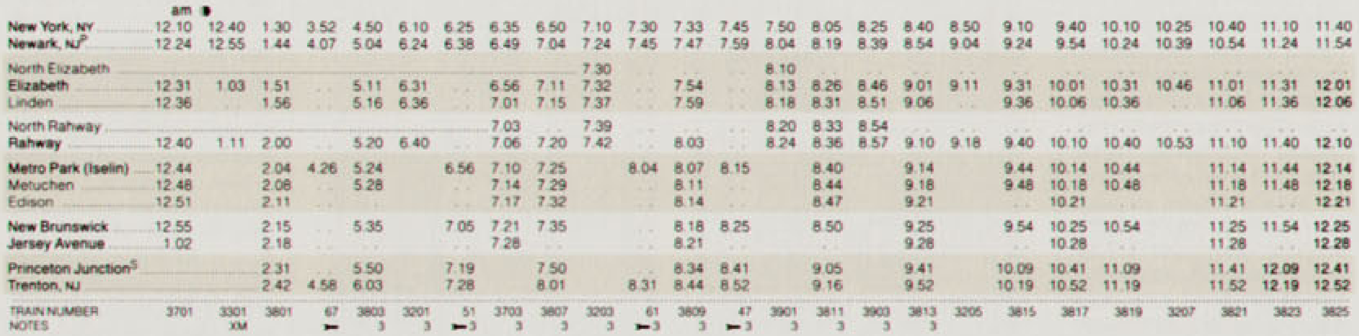
What matters—inevitably, unrelentingly—is the proper *relationship* among information layers. These visual relationships must be in relevant proportion and in harmony to the substance of the ideas, evidence, and data conveyed. "Proportion and harmony" need not be vague counsel; their meanings are revealed in the practice of detailed visual editing of data displays. For example, in this train timetable a heavy-handed grid interacts with the type, generating a stripy texture and fighting with the scheduled times. The prominent top position in the table shows the least important information, a four-digit train identifier used by railroad personnel and nobody else:

New Jersey Transit, *Northeastern Corridor Timetable* (Newark, 1985).



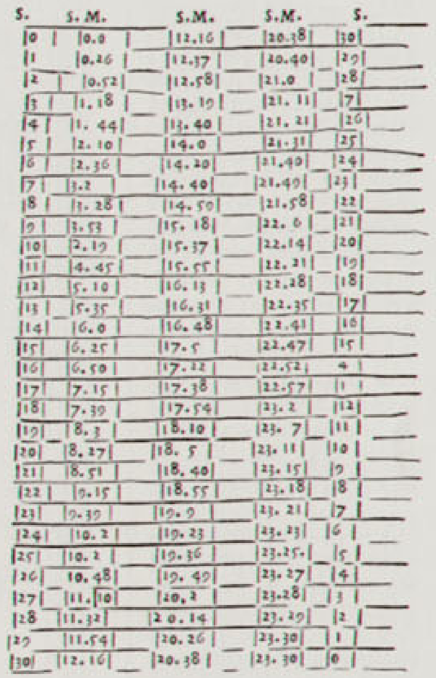
Train No.	3701	XM 3301	3801	A 67	3 3803	3 3201	A3 51	3 3703	3 3807	3 3203	A3 61	3 3809	A3 47	3 3901	3 3811	3 3903	3 3813	3205	3815	3817	3819	3207	3821	3823	3825	3209	3827	3829	3831
New York, N.Y.	A.M. 12.10	A.M. 12.40	A.M. 1.30	A.M. 3.52	A.M. 4.50	A.M. 6.10	A.M. 6.25	A.M. 6.35	A.M. 6.50	A.M. 7.10	A.M. 7.30	A.M. 7.33	A.M. 7.45	A.M. 7.50	A.M. 8.05	A.M. 8.25	A.M. 8.40	A.M. 8.50	A.M. 9.10	A.M. 9.40	A.M. 10.10	A.M. 10.25	A.M. 10.40	A.M. 11.10	A.M. 11.40	A.M. 11.50	P.M. **12.10**	P.M. **12.40**	P.M. **1.10**
Newark, N.J. P	12.24	12.55	1.44	4.07	5.04	6.24	6.38	6.49	7.04	7.24	7.45	7.47	7.59	8.04	8.19	8.39	8.54	9.04	9.24	9.54	10.24	10.39	10.54	11.24	11.54	**12.04**	**12.24**	**12.54**	**1.24**
North Elizabeth										7.30				8.10															
Elizabeth	12.31	1.03	1.51		5.11	6.31		6.56	7.11	7.32		7.54		8.13	8.26	8.46	9.01	9.11	9.31	10.01	10.31	10.46	11.01	11.31	**12.01**	**12.11**	**12.31**	**1.01**	**1.31**
Linden	12.36		1.56		5.16	6.36		7.01	7.15	7.37		7.59		8.18	8.31	8.51	9.06		9.36	10.06	10.36		11.06	11.36	**12.06**		**12.36**	**1.06**	**1.36**
North Rahway								7.03		7.39				8.20	8.33	8.54													
Rahway	12.40	1.11	2.00		5.20	6.40		7.06	7.20	7.42		8.03		8.24	8.36	8.57	9.10	9.18	9.40	10.10	10.40	10.53	11.10	11.40	**12.10**	**12.18**	**12.40**	**1.10**	**1.40**
Metro Park (Iselin)	12.44		2.04	4.26	5.24		6.56	7.10	7.25		8.04	8.07	8.15		8.40		9.14		9.44	10.14	10.44		11.14	11.44	**12.14**		**12.44**	**1.14**	**1.44**
Metuchen	12.48		2.08		5.28			7.14	7.29			8.11			8.44		9.18		9.48	10.18	10.48		11.18	11.48	**12.18**		**12.48**	**1.18**	**1.48**
Edison	12.51		2.11					7.17	7.32			8.14			8.47		9.21			10.21			11.21		**12.21**			**1.21**	
New Brunswick	12.55		2.15		5.35		7.05	7.21	7.35			8.18	8.25		8.50		9.25		9.54	10.25	10.54		11.25	11.54	**12.25**		**12.54**	**1.25**	**1.54**
Jersey Avenue	1.02		2.18					7.28				8.21					9.28			10.28			11.28		**12.28**			**1.28**	
Princeton Jct. S			2.31		5.50		7.19		7.50			8.34	8.41		9.05		9.41		10.09	10.41	11.09		11.41	**12.09**	**12.41**		**1.09**	**1.41**	**2.09**
Trenton, N.J.			2.42	4.58	6.03		7.28		8.01		8.31	8.44	8.52		9.16		9.52		10.15	10.52	11.19		11.52	**12.19**	**12.52**		**1.22**	**1.52**	**2.20**

A redesign calms the dominating grid, moves the New York departure times to the very top, de-emphasizes less important data, and adds new information. A separating line is formed by tiny leader dots, which read as gray, making a distinction but not a barricade:



	am	●																							
New York, NY	12.10	12.40	1.30	3.52	4.50	6.10	6.25	6.35	6.50	7.10	7.30	7.33	7.45	7.50	8.05	8.25	8.40	8.50	9.10	9.40	10.10	10.25	10.40	11.10	11.40
Newark, NJP	12.24	12.55	1.44	4.07	5.04	6.24	6.38	6.49	7.04	7.24	7.45	7.47	7.59	8.04	8.19	8.39	8.54	9.04	9.24	9.54	10.24	10.39	10.54	11.24	11.54
North Elizabeth										7.30				8.10											
Elizabeth	12.31	1.03	1.51		5.11	6.31		6.56	7.11	7.32		7.54		8.13	8.26	8.46	9.01	9.11	9.31	10.01	10.31	10.46	11.01	11.31	**12.01**
Linden	12.36		1.56		5.16	6.36		7.01	7.15	7.37		7.59		8.18	8.31	8.51	9.06		9.36	10.06	10.36		11.06	11.36	**12.06**
North Rahway								7.03		7.39				8.20	8.33	8.54									
Rahway	12.40	1.11	2.00		5.20	6.40		7.06	7.20	7.42		8.03		8.24	8.36	8.57	9.10	9.18	9.40	10.10	10.40	10.53	11.10	11.40	**12.10**
Metro Park (Iselin)	12.44		2.04	4.26	5.24		6.56	7.10	7.25		8.04	8.07	8.15		8.40		9.14		9.44	10.14	10.44		11.14	11.44	**12.14**
Metuchen	12.48		2.08		5.28			7.14	7.29			8.11			8.44		9.18		9.48	10.18	10.48		11.18	11.48	**12.18**
Edison	12.51		2.11					7.17	7.32			8.14			8.47		9.21			10.21			11.21		**12.21**
New Brunswick	12.55		2.15		5.35		7.05	7.21	7.35			8.18	8.25		8.50		9.25		9.54	10.25	10.54		11.25	11.54	**12.25**
Jersey Avenue	1.02		2.18					7.28				8.21					9.28			10.28			11.28		**12.28**
Princeton JunctionS			2.31		5.50		7.19		7.50			8.34	8.41		9.05		9.41		10.09	10.41	11.09		11.41	**12.09**	**12.41**
Trenton, NJ			2.42	4.58	6.03		7.28		8.01		8.31	8.44	8.52		9.16		9.52		10.19	10.52	11.19		11.52	**12.19**	**12.52**
TRAIN NUMBER	3701	3301	3801	67	3803	3201	51	3703	3807	3203	61	3809	47	3901	3811	3903	3813	3205	3815	3817	3819	3207	3821	3823	3825
NOTES		XM		➡	3	3	➡ 3	3	3	3	➡ 3	3	➡ 3	3	3	3	3								

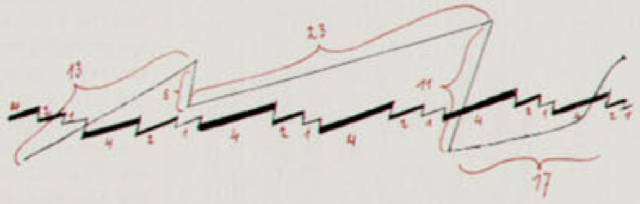
The focus is now given over to information, transparently organized by an *implicit* typographical grid, defined simply by the absence of type. Nevertheless, data-imprisonment spans centuries of information-design struggles. At right is a touchingly ramshackle grid from a 1535 edition of *Cosmographia*. But, from the virtuoso of typographic design: "Tables should not be set to look like nets with every number enclosed," wrote Jan Tschichold in *Asymmetric Typography:*

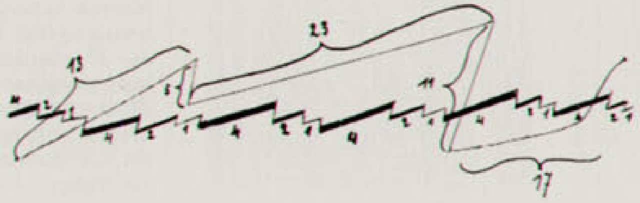


S.	S. M.	S.M.	S.M.	S.
0	0.0	12.16	20.38	30
1	0.26	12.37	20.40	29
2	0.52	12.58	21.0	28
3	1.18	13.19	21.11	7
4	1.44	13.40	21.21	26
5	2.10	14.0	21.31	25
6	2.36	14.20	21.40	24
7	3.2	14.40	21.49	23
8	3.28	14.59	21.58	22
9	3.53	15.18	22.6	21
10	2.19	15.37	22.14	20
11	4.45	15.55	22.21	19
12	5.10	16.13	22.28	18
13	5.35	16.31	22.35	17
14	6.0	16.48	22.41	16
15	6.25	17.5	22.47	15
16	6.50	17.22	22.52	4
17	7.15	17.38	22.57	1
18	7.39	17.54	23.2	12
19	8.3	18.10	23.7	11
20	8.27	18.5	23.11	10
21	8.51	18.40	23.15	9
22	9.15	18.55	23.18	8
23	9.39	19.9	23.21	7
24	10.2	19.23	23.23	6
25	10.2	19.36	23.25.	5
26	10.48	19.49	23.27	4
27	11.10	20.2	23.28	3
28	11.32	20.14	23.29	2
29	11.54	20.26	23.30	1
30	12.16	20.38	23.30	0

> The setting of tables, often approached with gloom, may with careful thought be turned into work of great pleasure. First, try to do without rules altogether. They should be used only when they are absolutely necessary. Vertical rules are needed only when the space between columns is so narrow that mistakes will occur in reading without rules. Tables without vertical rules look better; thin rules are better than thick ones.[2]

Even quite small changes in line can have significant visual effects. For Paul Klee's sketch, the easy and graceful separation of black line and red commentary collapses into a mishmash when color and light/dark differences are minimized:





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[2] Jan Tschichold, *Asymmetric Typography* (Basel, 1935; Toronto, 1967), p. 62.

Paul Klee, *Symptomatic*. Pen and ink drawing, 1927/F2. From *Das bildnerische Denken* (Basel, 1956), p. 300.

Separate macro-annotation explains the micro-detail of hospital costs in this 26-day narrative of one person passing through an intensive care unit. The design is transparent to the disturbing information, as a layered polyphony of voices—time sequence, accounting data, commentary—weave together to trace out days, hours, minutes, dollars.

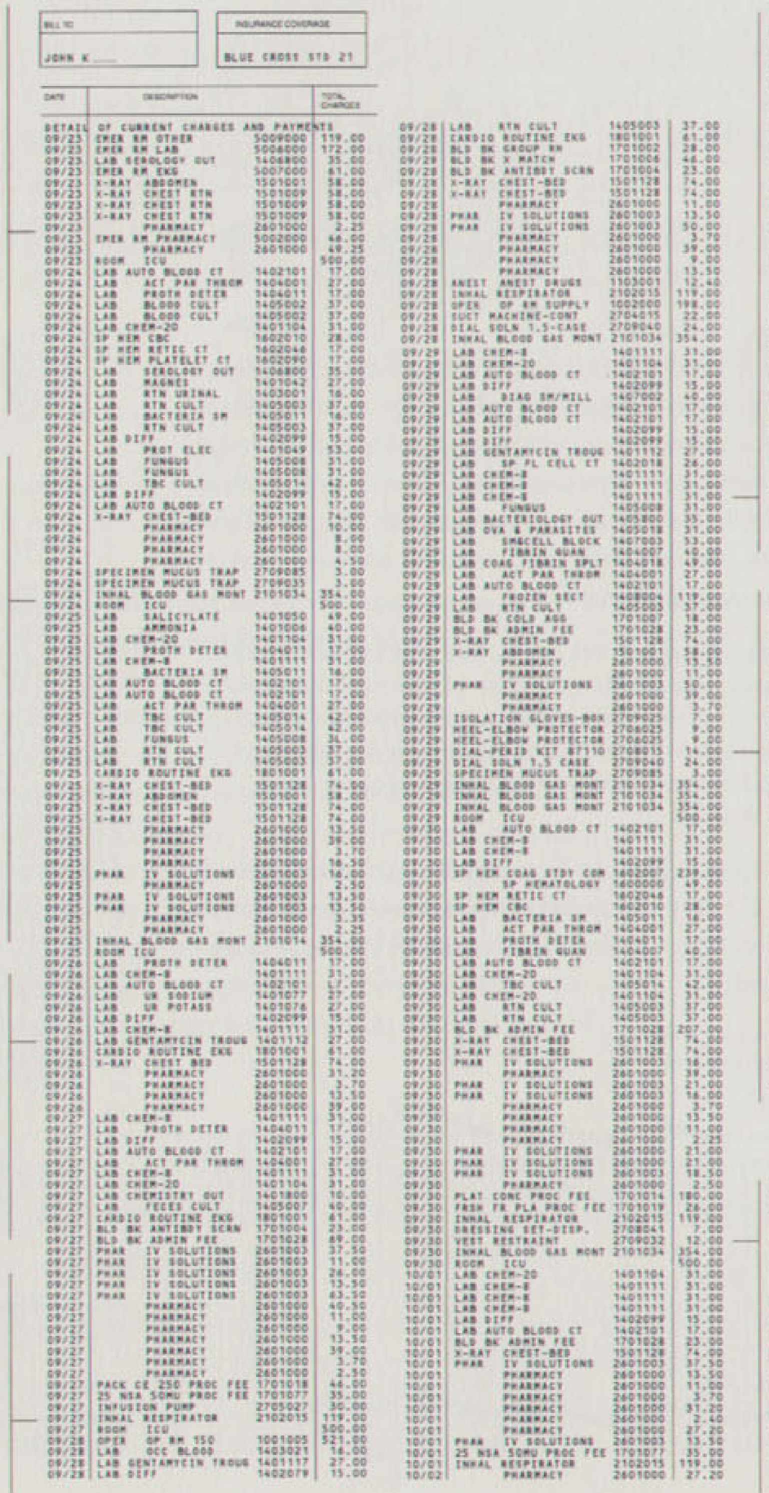
Redrawn from David Hellerstein, "The Slow, Costly Death of Mrs. K____," *Harper's*, 268 (March 1984), 84–89.

Mrs. K____ has been taken to the emergency room of a renowned hospital on Manhattan's Upper East Side. The doctors "work her up." More than $200 worth of blood tests are ordered ("emer rm lab," "lab serology out"), $232 worth of X-rays taken, $97.50 worth of drugs administered. I never saw Mrs. K____, she wasn't in my hospital, I don't know her medical history. But I am a doctor, and can reconstruct from her hospital bill what is going on, more or less. She is sick, very sick.

Mrs. K____ has been moved to the Intensive Care Unit ("room ICU"). It costs $500 a day to stay in the ICU, base rate. California has the highest average ICU rates in the country: $632 a day. In Mississippi, the average is $265. ICUs were developed in the 1960s. They provide technological life-support systems and allow for extraordinary patient monitoring. An inhalation blood-gas monitor ("inhal blood gas mont") is being used to keep a close check on the amount of oxygen in her blood. Without the attention she is receiving in the ICU, Mrs. K____ might already be dead.

Mrs. K____ has been running a high fever. The doctors have sent cultures of her blood, urine, and sputum to the lab to find out why. She is put on gentamicin ("lab gentamycin troug"), a powerful antibiotic. Such strong drugs can have toxic side effects. Gentamicin kills bacteria, but can also cause kidney failure.

It is Mrs. K____'s fifth day at the hospital, and she is slipping closer to death: her lungs begin to fail. She is put on a respirator ("inhal respirator"), which costs $119 a day to rent and requires a special technician to operate. A hospital can buy the machine for about $15,000.



Mrs. K____'s first week in Intensive Care ends in a flourish of blood tests. She has five Chem-8s ("lab chem-8")—tests that measure the levels of sodium, potassium, and six other chemicals in her blood. The hospital charges Mrs. K____ $31 for each Chem-8. Most independent labs charge about half as much; some hospitals charge up to $60. The *New England Journal of Medicine* has said: "The clinical laboratory [is] a convenient profit center that can be used to support unrelated deficit-producing hospital operations." The *Annals of Internal Medicine* estimates that the number of clinical lab tests being done is rising 15 percent a year.

Mrs. K____ has started peritoneal dialysis ("dial-perid kit 87110"). Her kidneys are failing. She is still hooked up to the respirator. She is being kept alive by what Lewis Thomas calls "halfway technologies" — "halfway" because kidney dialysis machines and respirators can support organ systems for long periods of time, but can't cure the underlying disease. Some doctors are beginning to question this practice. A recent study at the George Washington University Medical Center concluded: "Substantial medical resources are now being used in aggressive but frequently futile attempts to avoid death."

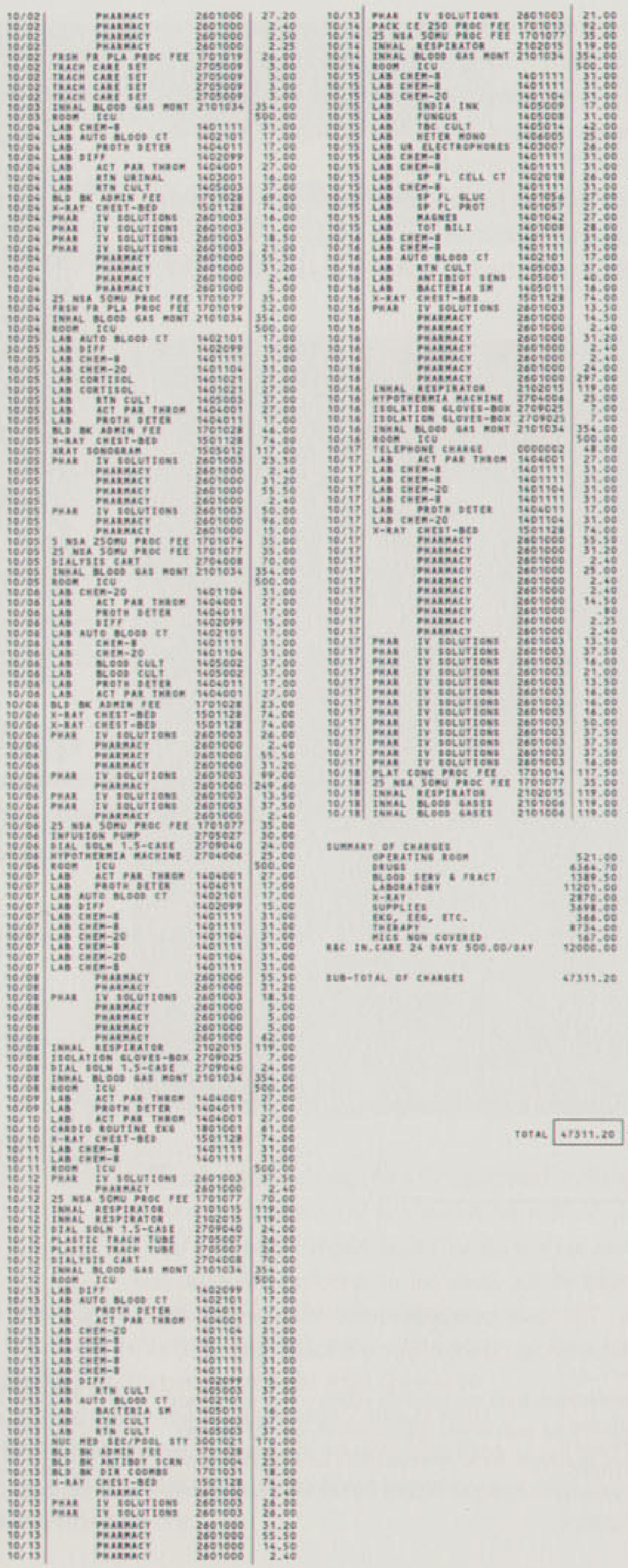
Mrs. K____ has been put in a vest restraint. Restraints are used in Intensive Care to keep patients from thrashing about or pulling their tubes out. Many ICU patients develop what is called "ICU psychosis." They become disoriented, begin hallucinating. The condition is brought on by lack of sleep, toxic drugs, the noise of the ICU staff and machines, and pain.

Mrs. K____ has been on the respirator for six days. It is breathing for her. But there has been a problem. The tube running from the machine into her mouth and down her throat was not bringing enough oxygen to her lungs. She needed a tracheotomy ("trach care set"). The tube from the respirator is now attached directly to her trachea, through a hole cut into her neck.

This charge—for a blood product ("5 NSA 250MU proc fee")—is not covered by Mrs. K____'s Blue Cross policy. The policy also does not cover the cost of fresh blood plasma ("frsh fr pla proc fee"). These charges have been mounting. Mrs. K____ is bleeding internally.

Mrs. K____ has been in Intensive Care for two weeks. She is still running a very high fever. The doctors are still testing. Mrs. K____ has been placed on a special blanket; it is hooked up to a machine that functions like a refrigerator ("hypothermia machine"). The machine cools the blanket, and the blanket helps lower Mrs. K____'s body temperature. Should her temperature rise too high, she may suffer permanent brain damage.

Mrs. K____ has undergone a gated blood-pool study ("nuc med sec/pool sty"). The doctors have "tagged" her red blood cells with a radioactive isotope. Using a camera that picks up the isotope, the doctors can watch the passage of blood through her heart. In this way, they see firsthand whether the ventricles are functioning properly—whether enough blood is getting pumped, enough oxygen is being sent through the body. First her lungs, then her kidneys. Now Mrs. K____'s heart seems to be going.



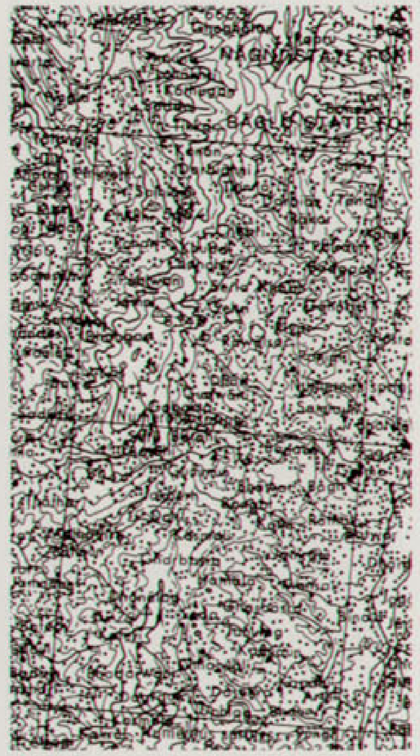
Mrs. K____'s fourth week in the hospital begins with a spinal tap. Using a long needle, a doctor drains fluid from her spinal cord. The fluid is sent to the lab for about a dozen tests ("lab sp fl cell ct"). A spinal tap is performed when a patient has what are called "neurological signs." Partial paralysis is one such sign, loss of consciousness another. When doctors order a spinal tap, they suspect brain disease.

Weeks of halfway technology have given the doctors time for testing. The doctors may even have diagnosed what is wrong with Mrs. K____; it is hard to say. But the ICU and its technology have not given them the ability to cure her. Now the heart, which has been failing, gives out. Cardiac arrest. There is a burst of activity. Bicarbonate, epinephrine, and other drugs ("pharmacy") are administered. Thirteen bottles of intravenous solution ("phar iv solutions") are poured in.

Mrs. K____'s last minutes are recorded on the various ICU monitors. The level of oxygen in her blood falls. She dies.

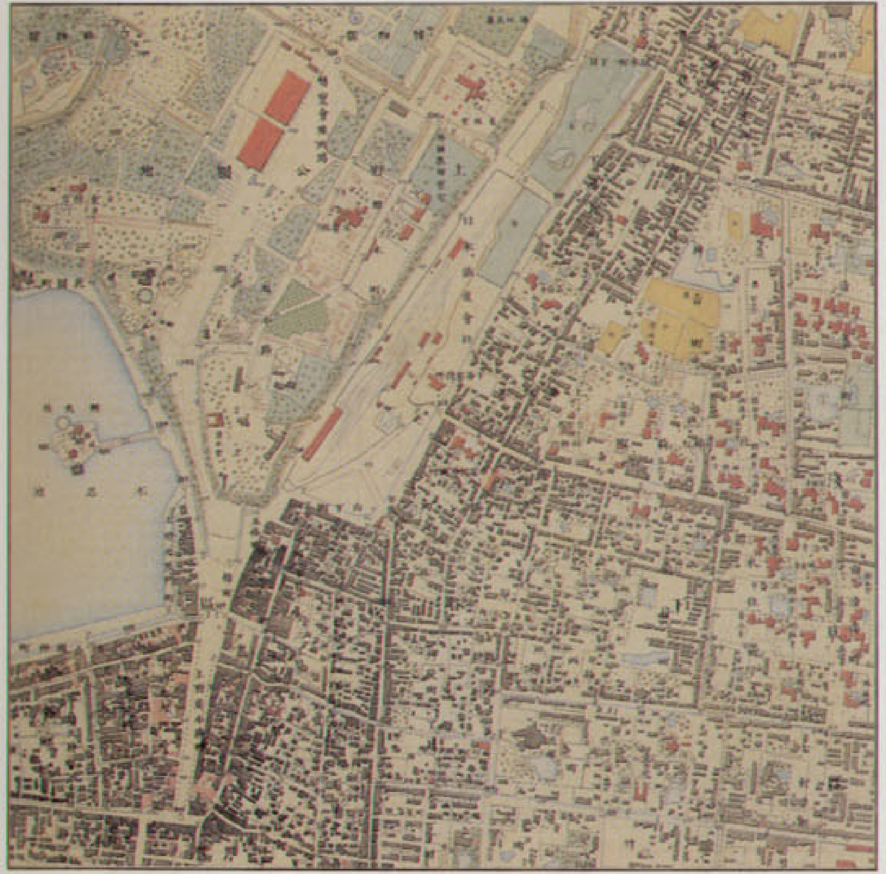
Mrs. K____'s bottom line. Total cost of twenty-six days in the hospital, nearly all this time in Intensive Care: $47,311.20. Of this, Blue Cross will pay $41,933.87. The doctors' bills, not covered by hospitalization insurance, probably come to thousands of dollars more. Perhaps Mrs. K____ had Blue Shield, which covers doctors' fees. In 1982, the last year for which figures are available, Americans spent $322 billion on health care. Of this, $135.5 billion was spent on hospital care. There were 56,241 ICU beds in 1982 like the one Mrs. K____ was kept alive in, and about $27 billion was spent for their use. That represented nearly one percent of the gross national product.

All elements in the map at right—contours, rivers, roads, names—are at the same visual level with equal values, equal texture, equal color, and even nearly equal shape. An undifferentiated, unlayered surface results, jumbled up, blurry, incoherent, chaotic with unintentional optical art. What we have here is a failure to communicate.



Simla, India (U.S. Army map series U 502, NH 43-4, 1954), based on the Survey of India, 1921–1943.

Far more detailed than the perfect jumble, this map below separates and layers information by means of distinctions in shape, value (light to dark), size, and especially color. The negative areas are also informative; light strips formed by the grid of buildings identify roads and paths. The water symbol is a blue field, further differentiated from other color fields by a gentle fading away from each outlined edge. Shown against a dull background rather than bright white, these colors remain both calm and distinctive, avoiding clutter. The map exemplifies the "first rule of color composition" of the illustrious Swiss cartographer, Eduard Imhof:



Tokyo Prefecture. Musashino, Ueno Park, Kurumazaka area (Tokyo, 1884).

> Pure, bright or very strong colors have loud, unbearable effects when they stand unrelieved over large areas adjacent to each other, but extraordinary effects can be achieved when they are used sparingly on or between dull background tones. "Noise is not music . . . only on a quiet background can a colorful theme be constructed," claims Windisch.[3]

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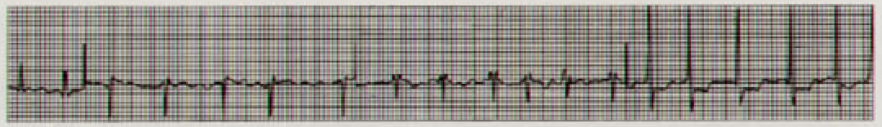
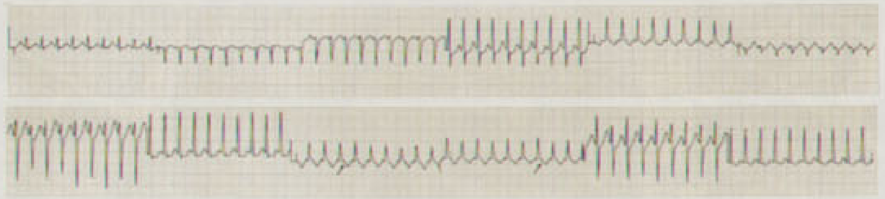
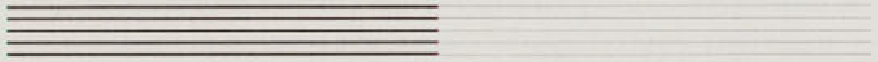
[3] Eduard Imhof, *Cartographic Relief Presentation* (Berlin, 1982), edited and translated by H. J. Steward from Imhof's *Kartographische Geländedarstellung* (Berlin, 1965), p. 72. The internal quotation is from H. Windisch, *Schule der Farbenphotographie* (Seebruck, 6th edition, 1958).



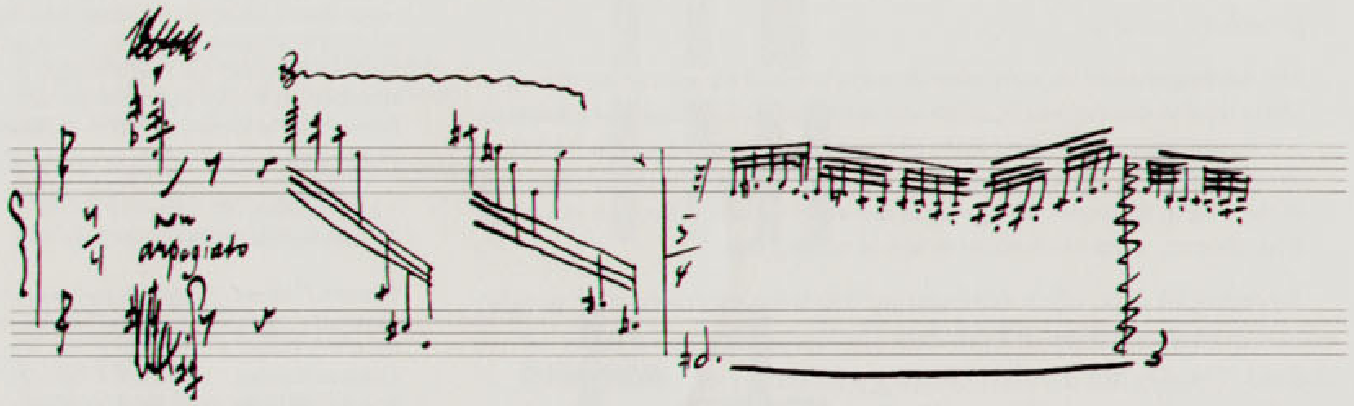
Signal and background compete above, as an electrocardiogram trace-line becomes caught up in a thick grid. Below, the screened-down grid stays behind traces from each of 12 monitoring leads:[4]



Similarly for music notation, some staff paper is better than others:



In Stravinsky's sketchbook for *Sacre du printemps*, a grid quietly but clearly and precisely locates the music. Gray grids almost always work well and, with a delicate line, may promote more accurate data reading and reconstruction than a heavy grid. Dark grid lines are chartjunk. When a graphic serves as a look-up table (rare indeed), then a grid may help with reading and interpolation. But even then the grid should be muted relative to the data. Often ready-made graph paper comes with darkly printed lines. The reverse unprinted side should be used, for then lines show through faintly and do not clutter the data. If the paper is heavily gridded on both sides, throw it out.



Igor Strawinsky, *Sacre-Skizzenbuch*, p. 135, top; Paul Sacher Stiftung, Kunstmuseum Basel, and in Hans Oesch, "Im Schatten des *Sacre du printemps* Beobachtungen zu den Trois poésies de la lyrique japonaise, einem Schlüsselwerk von Igor Strawinsky," *Komponisten des 20. Jahrhunderts in der Paul Sacher Stiftung* (Basel, 1986), p. 100.

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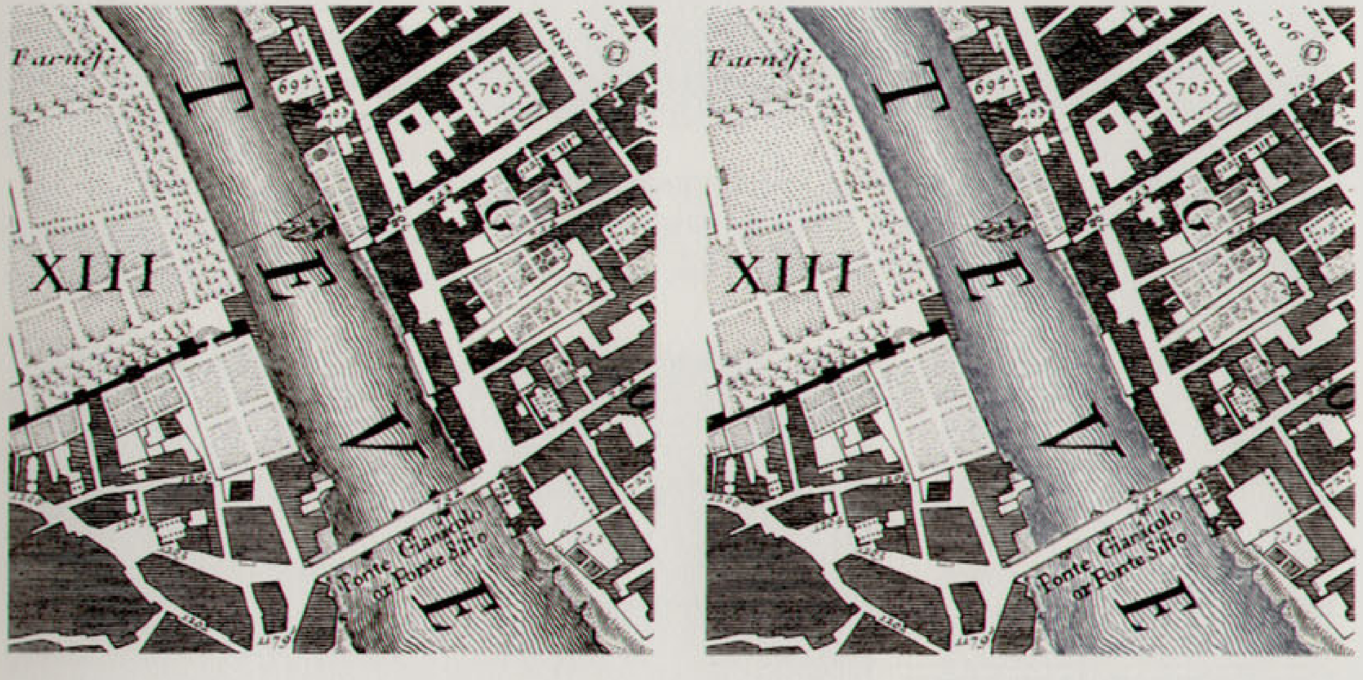
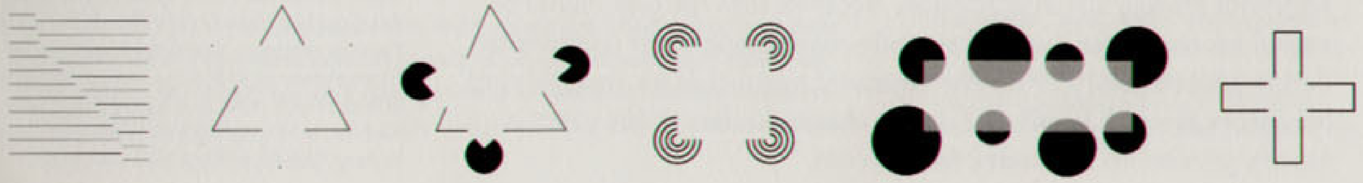
[4] The preferred example is redrawn from J. Marcus Wharton and Nora Goldschlager, *Interpreting Cardiac Dysrhythmias* (Oradell, New Jersey, 1987), p. 123. Color also layers, as a gray grid calibrates this signal of ventricular fibrillation, a final collapse of the heart, with only a disorganized rhythm remaining. A similar trace can result from recording artifacts such as a loose monitoring wire; however, one textbook dryly notes, "As the patient will usually have lost consciousness by the time you have realized that it is not just due to a loose connection, diagnosis is easy." John R. Hampton, *The ECG Made Easy* (Edinburgh, 1986), p. 66.



In the masterly 1748 Nolli map of Rome, the river's heavy inking activates what should be a visually tranquil area, causing bridge names and a little boat to vibrate in a moiré prison, albeit a quiet one. Muting the river encoding calms vibration and brings names and other details forward, while retaining a symbolism of rippling water.[5] This redesign and others that we have seen are visual equivalents of Italo Calvino's approach to writing:

> My working method has more often than not involved the subtraction of weight. I have tried to remove weight, sometimes from people, sometimes from heavenly bodies, sometimes from cities; above all I have tried to remove weight from the structure of stories and from language. . . . Maybe I was only then becoming aware of the weight, the inertia, the opacity of the world—qualities that stick to writing from the start, unless one finds some way of evading them.[6]

Layering of data, often achieved by felicitous subtraction of weight, enhances representation of both data dimensionality and density on flatland. Usually this involves creating a hierarchy of visual effects, possibly matching an ordering of information content. Small, modest design moves can yield decisive visual results, as in these intriguing demonstrations of the illusory borders of subjective contours:



Gaetano Kanizsa, "Contours without Gradients or Cognitive Contours?" *Italian Journal of Psychology*, 1 (April 1974), 93–112; and Gaetano Kanizsa, "Subjective Contours," *Scientific American*, 234 (April 1976), 48–52.

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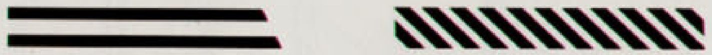
[5] Giambattista Nolli, *Pianta Grande di Roma* (Rome, 1748; from a facsimile edition by J. H. Aronson, Highmount, New York, 1984). Note the seemingly English word "or" in the names under the bridge, a result of the 18th-century custom of contracting the Italian *ora*, meaning *now*, *at this time*, *currently*. On his map, Nolli cites first the old name *Ponte Gianicolo or[a] Ponte Sisto* (the bridge's new name). Ironically, the English "or" works in this context, although the meaning is not quite right. See Barbara Reynolds, *The Cambridge Italian Dictionary, Italian-English* (Cambridge, 1962), p. 521.

[6] Italo Calvino, *Six Memos for the Next Millennium* (Cambridge, 1988), pp. 3–4.

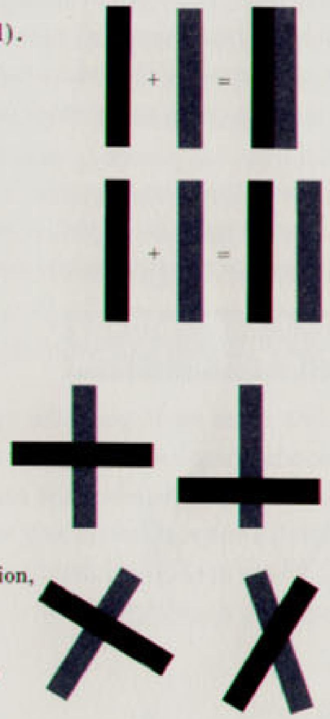
Visual activation of negative areas of white space in these exhibits illustrates *the endlessly contextual and interactive nature of visual elements.* This idea is captured in a fundamental principle of information design: *$1 + 1 = 3$ or more.* In the simplest case, when we draw two black lines, a third visual activity results, a bright white path between lines (note that this path appears even to have an angled end). And a complexity



of marks generates an exponential complexity of negative shapes. *Most of the time, that surplus visual activity is non-information, noise, and clutter.*[7] This two-step logic—recognition of $1 + 1 = 3$ effects and the consideration that they generate noise—provides a valuable guide for refining and editing designs, for graphical reasoning, for subtraction of weight.[8]

In a little-known essay on $1 + 1 = 3$ effects, Josef Albers conducts the demonstrations below, a visually sensitive and artistic approach to the cognitive contours of perceptual psychologists. Albers, seeing area and surface rather than border and edge, escapes the preoccupying magic of optical illusions to conceive a broad idea of negative space activation:

Here I have 2 equal strips of cardboard (1" x 6")



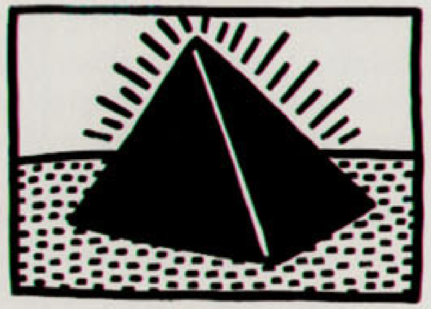
Here is one (vertical), here another (also vertical).
Seeing one strip plus one strip, we count 2 strips:
$1 + 1 = 2$.

We recognize the equal width of the strips.
Now, 1 width + 1 width (strips touching)
equals 2 widths: $1 + 1 = 2$.

But now, separating them (both remain vertical)
by 1 width — we count 3 widths
(one of them negative): $1 + 1 = 3$.

Of the 2 vertical strips,
one crosses the other horizontally
in their centers.
Result: 2 lines form a crossing
thus producing 4 arms, as 4 extensions,
to be read inward as well as outward.
We also see 4 rectangles, and with some imagination,
4 triangles, 4 squares.
By shifting centers and angles,
arms and the in-between figures become unequal.

All together: one line plus one line
results in many meanings — *Quod erat demonstrandum.*



Keith Haring, Untitled 4/29/82, sumi ink on paper. © 1992 Estate of Keith Haring.

Josef Albers, "One Plus One Equals Three or More: Factual Facts and Actual Facts," in Albers, *Search Versus Re-Search* (Hartford, 1969), pp. 17–18.

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[7] Rare exceptions are the Turgot-Bretez map of Paris and the Nolli map of Rome: streets, absent of ink, are defined—tersely, clearly, and precisely—by the surrounding ink of blocks and buildings, creating subjective contours.

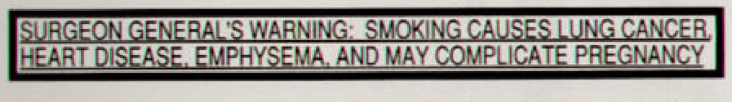
[8] Note the additional $1 + 1 = 3$ effects, on this page, as the interaction between the examples and the surrounding type enlivens the white space, forming shapes, profiles, and paths. These reverberations are vivid because our examples are printed in black; strong light/dark contrasts accentuate the clutter of $1 + 1 = 3$ or more.

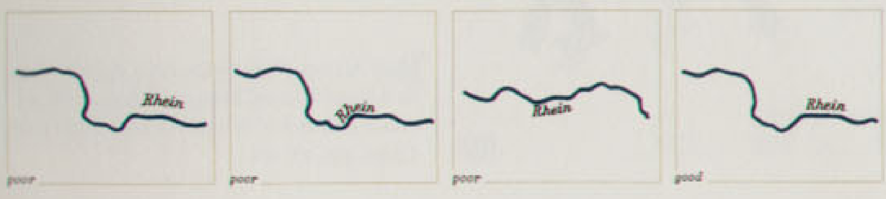
Stumbling over 1 + 1 = 3 has produced perhaps the worst index ever designed, a rare perfect failure. The preface to this guide for flying small aircraft says, "This manual is primarily intended for use during actual flight instruction." Imagine now noisy vibration in a plane as we search through this visually vibrating list, looking for, say, an entry on "forced landing" . . . and the index turns out to have no page numbers. Only a small segment of the unbearable original is shown.

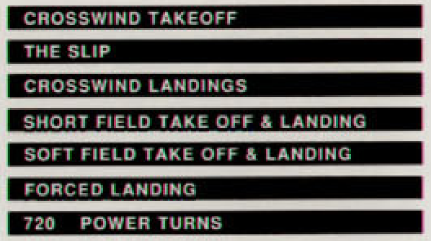
The noise of 1 + 1 = 3 is directly proportional to the contrast in value (light/dark) between figure and ground. On white backgrounds, therefore, a varying range of lighter colors will minimize incidental clutter. Three maps at right show these tactics in action. In the first, the bold shapes promote vibration all over; and with only nameless streets down on paper, this map is already in visual trouble. At center, thinning two sides of each block results in every street bordered by one thick *and* one thin line, thus deflecting 1 + 1 = 3 effects (the thin lines, like gray lines, are *visually* light in value). On the bottom map, gray establishes serene, motionless edges—an arrangement that will easily accommodate additional geographic detail.

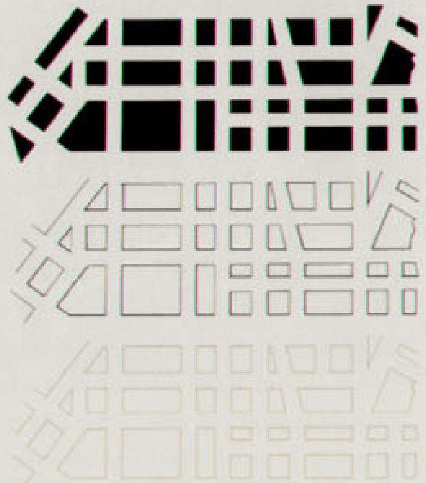
Careful visual editing diminishes 1 + 1 = 3 clutter. These are not trivial cosmetic matters, for signal enhancement through noise reduction can reduce viewer fatigue as well as improve accuracy of readings from a computer interface, a flight-control display, or a medical instrument. Clarity is not everything, but there is little without it. Editing this statistical graph (showing variability about local averages) remedies the visual clutter induced by parallel lines and equal-width white bands. The redesign, at far right, sweeps the noise away, with color spots now smartly tracking the path of averages.

Harmonizing text and line-drawing requires sensitive appraisals of prolific interaction effects. Unless deliberate obscurity is sought, avoid surrounding words by little boxes, which activate negative white spaces between word and box. And below, the first three maps place the type poorly, with an awkward white stripe materializing between name and river. Type from above adjusts to graphics better, in part because most words have fewer descenders than ascenders (in map 3, a diverting white shape is formed by the ascending letters).[9] These small local details will promptly accumulate on the entire map surface, deciding quality.

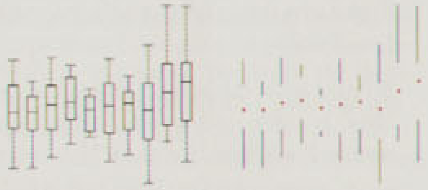

SURGEON GENERAL'S WARNING: SMOKING CAUSES LUNG CANCER, HEART DISEASE, EMPHYSEMA, AND MAY COMPLICATE PREGNANCY



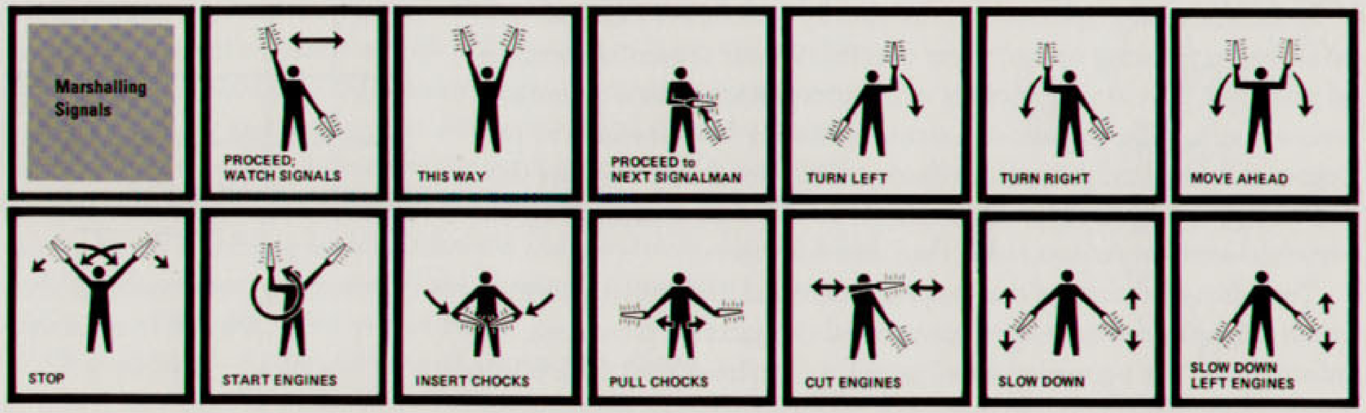

CROSSWIND TAKEOFF
THE SLIP
CROSSWIND LANDINGS
SHORT FIELD TAKE OFF & LANDING
SOFT FIELD TAKE OFF & LANDING
FORCED LANDING
720 POWER TURNS



Middle map above, student project by Jon Wertheimer, Studies in Graphic Design, Yale University, 1985–1986.

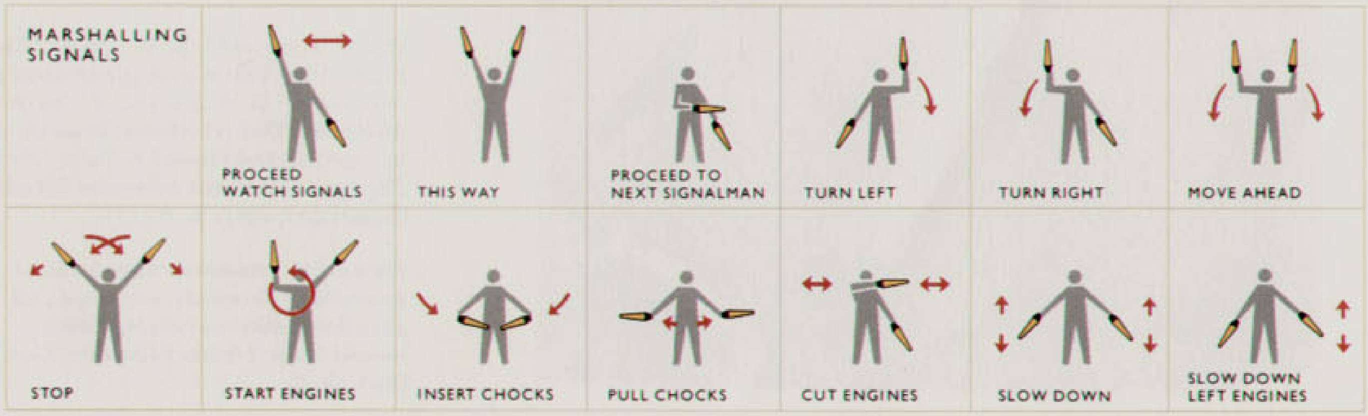


John W. Tukey, *Exploratory Data Analysis* (Reading, Massachusetts, 1977), p. 269; and, right, Edward R. Tufte, *The Visual Display of Quantitative Information* (Cheshire, Connecticut, 1983), p. 125.



This array above, an information prison, employs a narrow range of strong shapes. Grid, silhouette, and type compete at the same nervous visual level. Too loud and too similar. Thick bars of grid boxes generate little paths around both type and silhouette by exciting the negative white space: 1 + 1 = 3, all over again. Why should the trivial task of dividing up the already free-standing elements become the dominant statement of the entire display?

To direct attention toward the information at hand, the revision below extends the light to dark range of color, separating and layering the data in rough proportion to their relevance. Gray calms a contrasty silhouette, bringing about in turn more emphasis on the lamps and their position and motion. Coloring these lights helps to separate the signals from all the rest. Some 460 lamp-whiskers were erased, whiskers which originally read in confusion as glowing light and also trembling motion. Note the effectiveness and elegance of *small spots of intense, saturated color* for carrying information—a design secret of classical cartography[10] and, for that matter, of traffic lights. Finally, in our revised version, the type for the title (upper left corner) has emerged from its foggy closet. Also the labels, now set in Gill Sans, are no longer equal in visual weight to the motion arrows, among several typographical refinements.



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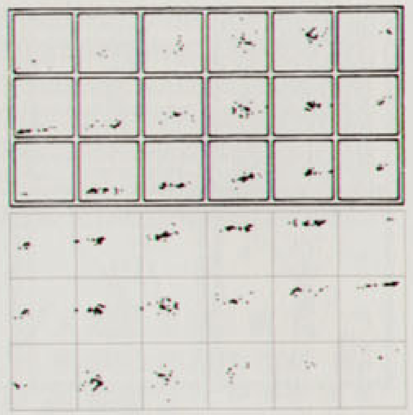
[9] Eduard Imhof, "Die Anordnung der Namen in der Karte," *International Yearbook of Cartography*, 2 (1962), 93–129; and, in English translation, "Positioning Names on Maps," *The American Cartographer*, 2 (1975), 128–144; showing here 4 of Imhof's total of 106 examples! Also, Paul Bühler, "Schriftformen und Schriftstellung unter besonderer Berücksichtigung der schweizerischen topographischen Kartenwerke," *International Yearbook of Cartography*, 1 (1961), 153–181.

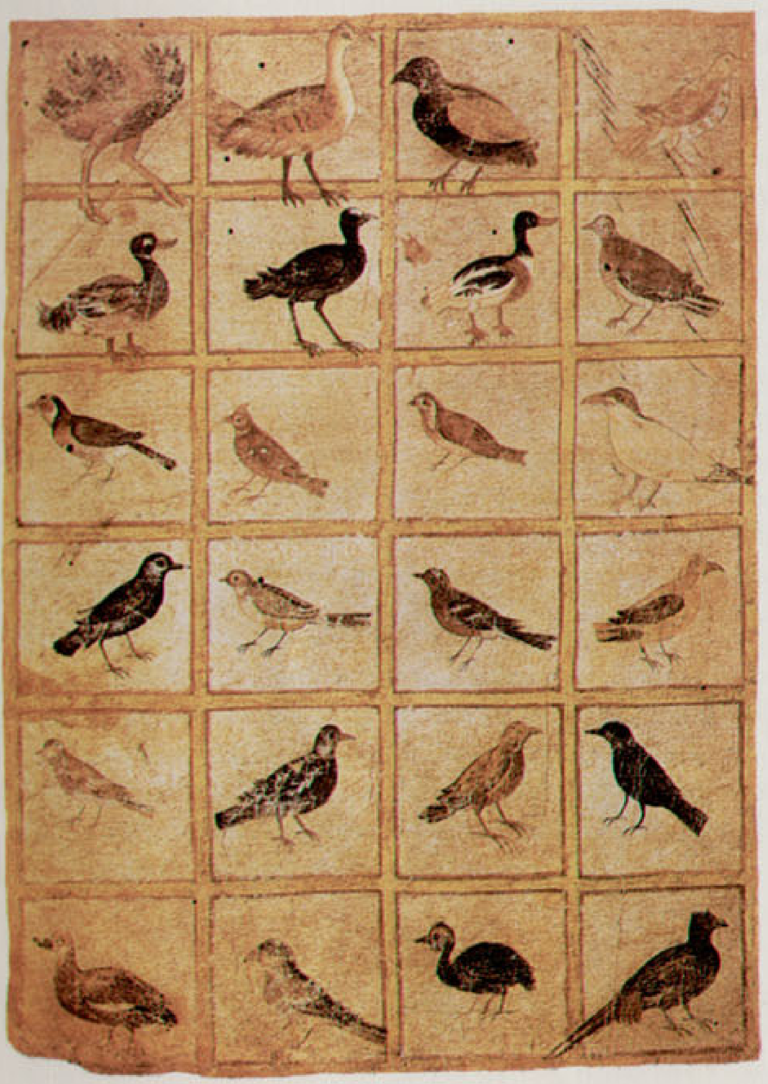
[10] "If one limits strong, heavy, rich, and solid colors to the small areas of extremes, then expressive and beautiful colored area patterns occur. . . . Large area background or base-colors do their work most quietly, allowing the smaller, bright areas to stand out most vividly, if the former are muted, grayish or neutral." Eduard Imhof, *Cartographic Relief Presentation* (Berlin, 1982), edited and translated by H. J. Steward from Imhof's *Kartographische Geländedarstellung* (Berlin, 1965), p. 72. On visual issues and map-making, see essays by Samuel Y. Edgerton, Jr., Svetlana Alpers, Juergen Schulz, Ulla Ehrensvärd, James A. Welu, and David Woodward, in Woodward, ed., *Art and Cartography* (Chicago, 1987).

In the statistical graphic at top, the visually most active elements are, of all things, glowing optical white dots that appear at each intersection of grid lines. (The arrangement of many computer interfaces is similarly overwrought.) The doubled-up, tremor-inducing lines consume 18 percent of this technically ingenious chart, a multi-window plot. Here the redrawing, in ungrid style, eliminates the visual noise, concentrating our viewer's attention on data rather than data containers.

Too often epidemics of data-imprisonment and decorative gridding break out when contemporary commercial designers are faced with information. The aggressive visual presence of stylized grids, little boxes surrounding words here and there, and cadenced accents—all so empty of content, irrelevant—becomes the only way you can tell if something has been "designed". At any rate, the self-important grid is for the birds, providing only a nice place to perch:



Paul A. Tukey and John W. Tukey, "Data-Driven View Selection; Agglomeration and Sharpening," in Vic Barnett, ed., *Interpreting Multivariate Data* (Chichester, England, 1981), pp. 231–232; and Edward R. Tufte, *The Visual Display of Quantitative Information* (Cheshire, Connecticut, 1983), p. 114.

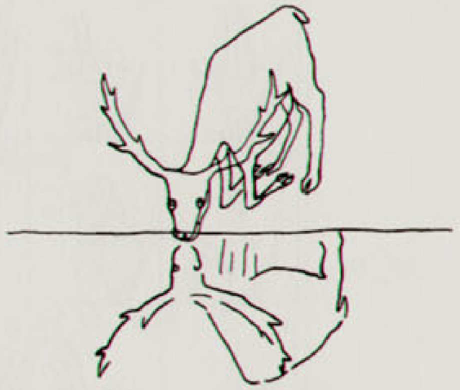


Dioscorides (Constantinopolitanus), De materia medica, 6th century, ca 512 A.D., fol. 483. Illumination on vellum, Vienna Österreichische Nationalbibliothek, Cod. Med. Gr. I.

INFORMATION consists of *differences that make a difference.* A fruitful method for the enforcement of such differences is to layer and separate data, much as is done on a high-density map. In representing various layers of meaning and reading, the most economical of means can yield distinctions that make a difference: the small gestures of Calder's pen easily separate the stag and his watery reflection. Failure to differentiate among layers of reading leads to cluttered and incoherent displays filled with disinformation, generated by the unrelenting interactive visual arithmetic of flatland, $1 + 1 = 3$ or more.

All these ideas—figure and ground, interaction effects, $1 + 1 = 3$ or more, layering and separation—have compelling consequences for information displays. Such concepts (operating under an assortment of names) are thoroughly tested, long familiar the world over in the flatlands of typographers, calligraphers, graphic designers, illustrators, artists, and, in three dimensions, architects:

> In every clear concept of the nature of vision and in every healthy approach to the spatial world, this dynamic unity of figure and background has been clearly understood. Lao Tse showed such grasp when he said: "A vessel is useful only through its emptiness. It is the space opened in a wall that serves as a window. Thus it is the nonexistent in things which makes them serviceable." Eastern visual culture has a deep understanding of the role of empty space in the image. Chinese and Japanese painters have the admirable courage to leave empty large paths of their picture-surface so that the surface is divided into unequal intervals which, through their spacing, force the eye of the spectator to movements of varying velocity in following up relationships, and thus create the unity by the greatest possible variation of surface. Chinese and Japanese calligraphy also have a sound respect for the white interval. Characters are written in imaginary squares, the blank areas of which are given as much consideration as the graphic units, the strokes. Written or printed communications are living or dead depending upon the organization of their blank spaces. A single character gains clarity and meaning by an orderly relationship of the space background which surrounds it. The greater the variety and distinction among respective background units, the clearer becomes the comprehension of a character as an individual expression or sign.[11]



Fables of Aesop, According to Sir Roger L'Estrange with drawings by Alexander Calder (Paris, 1931; New York, 1967), p. 1.

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[11] Gyorgy Kepes, *The Language of Vision* (Chicago, 1948).