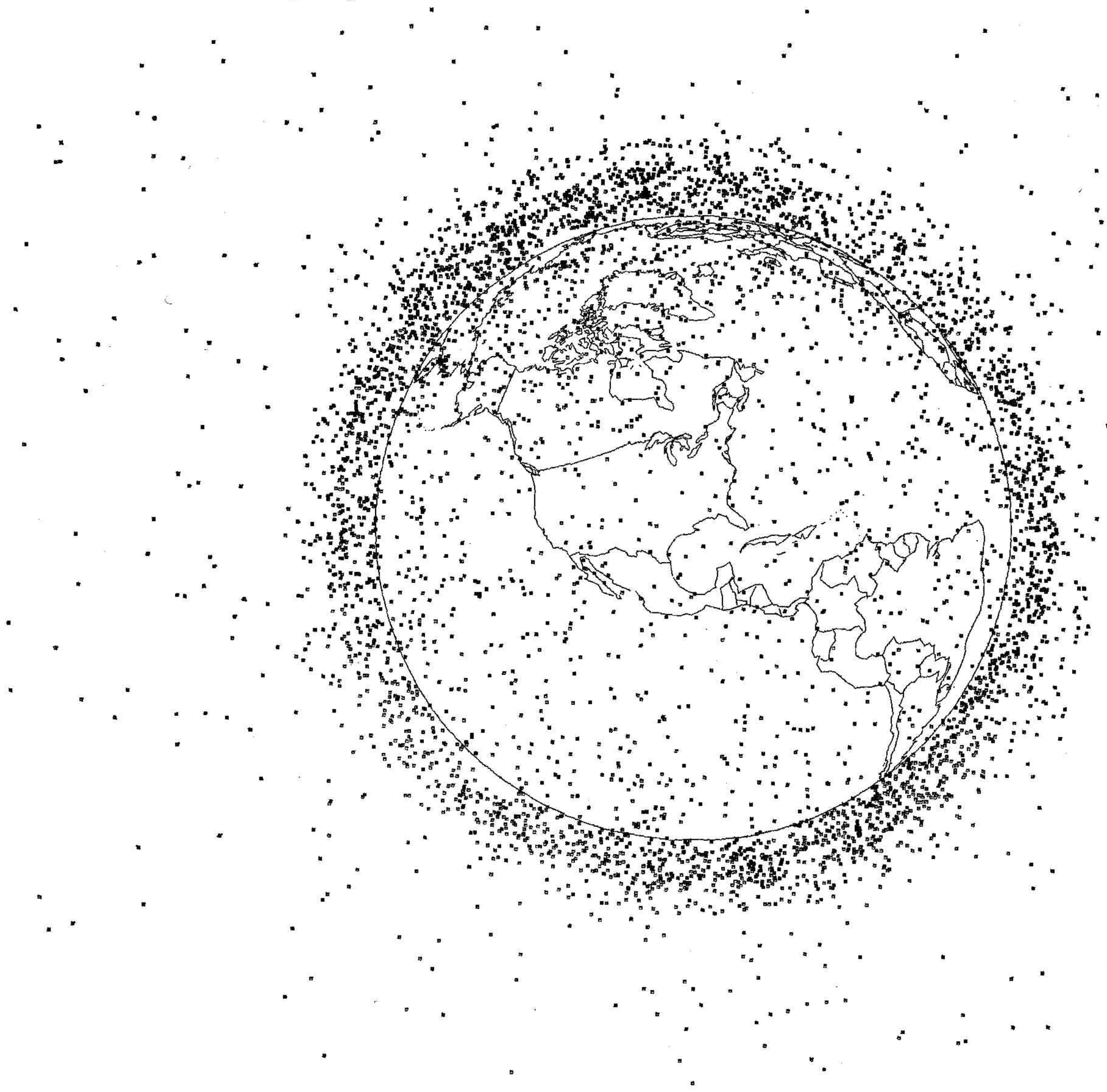
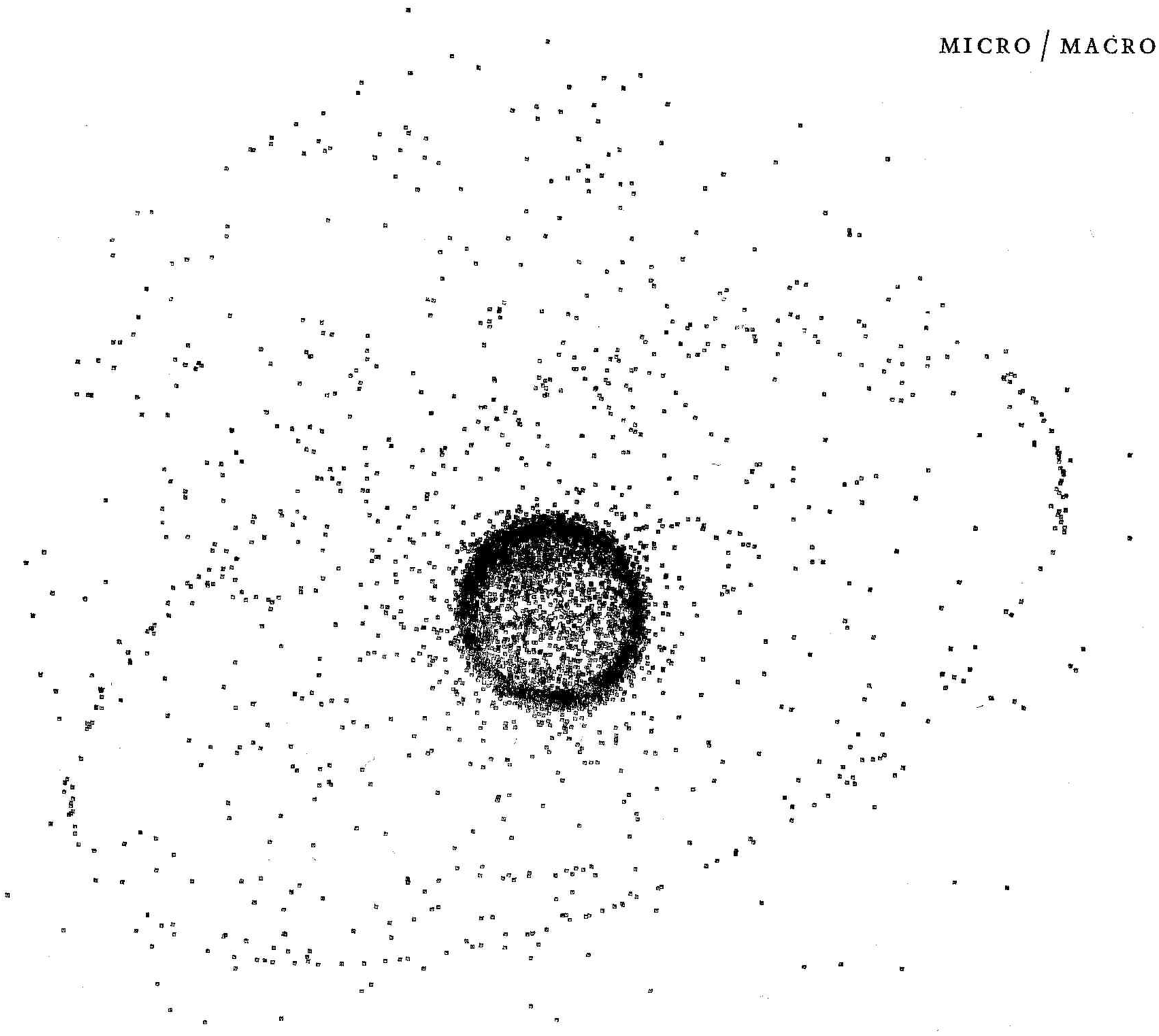
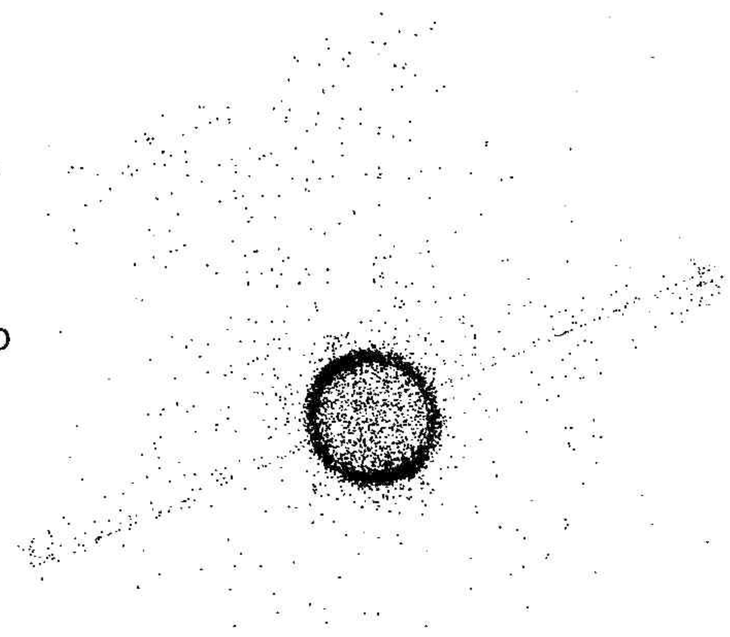
EACH at least as big as this drawing of the earth, some 7,000 pieces of space debris—operating and dead satellites, explosion fragments from rocket engines, garbage bags and frozen sewage dumped by astronauts, shrapnel from antisatellite weapons tests, 34 nuclear reactors and their fuel cores, an escaped wrench and a toothbrush—now orbit our world. Only about 5 percent are working satellites. By means of extraordinary data recording and analysis, military computers identify and then track *each* of these 7,000 objects (≥10 cm in diameter), in order to differentiate the debris from a missile attack, for which we may be thankful. Space is not totally self-cleaning; some of the stuff will be up there for centuries, endangering people and satellites working in space as well as inducing spurious astronomical observations. The risk of a damaging collision is perhaps 1 in 500 during several years in orbit. The volume of debris has doubled about every 5 years; future testing of space weapons will accelerate the trashing of space.[9]

[9] Donald J. Kessler and Burton G. Cour-Palais, "Collision Frequency of Artificial Satellites: The Creation of a Debris Belt," *Journal of Geophysical Research*, 83 (June 1, 1978), 2637–2646; Donald J. Kessler, "Earth Orbital Pollution," in Eugene C. Hargrove, ed., *Beyond Spaceship Earth* (San Francisco, 1986), 47–65; Nicholas L. Johnson, "History and Consequences of On-orbit Break-ups," in *Space Debris, Asteroids and Satellite Orbits*, D. J. Kessler, E. Grün, and L. Sehnal, eds., *Advances in Space Research*, 5 (Oxford, 1985), 11–19; Eliot Marshall, "Space Junk Grows with Weapons Tests," *Science*, 230 (October 25, 1985), 424–425; Joel R. Primack, "Gamma-Ray Observations of Orbiting Nuclear Reactors," *Science*, 244 (April 28, 1989), 407–408.





The consequences (as of 0:00 hours Universal time, July 1, 1987) are shown in these phenomenal and disheartening micro/macro images, as a multiplicity of 7,000 dots adds to the overall pattern of orbital pollution. Most of the debris is relatively close to earth; a more distant view shows a ring formed by geosynchronous satellites. Not shown are some 50,000 smaller objects (size between 1 cm and 10 cm), as well as 10 billion to 100 billion paint chips now in orbit.



NEARLY all micro/macro designs of this chapter have portrayed large quantities of data at high densities, up to thousands of bits per square centimeter and 20 million bits per page, pushing the limits of printing technology. Such quantities are thoroughly familiar, although hardly noticed: the human eye registers 150 million bits, the 35 mm slide some 25 million bits, conventional large-scale topographic maps up to 150 million bits, the color screen of a small personal computer 8 million bits. Typographic densities are also substantial; a few reference books report 28,000 characters per page, books on non-fiction best-seller lists from 5,000 to 15,000 characters per page, and the world's telephone books run between 10,000 and 18,000 characters per page. Statistical graphics and other information displays should do so well.

Illustrations provided by Nicholas L. Johnson, Teledyne Brown Engineering, Colorado Springs, Colorado. Dots are not to scale of Earth.