[82] While those factors for a diminishing yield of inventive effort may all be valid, there are the countervailing forces. Appropriate education, not only in engineering, but in physics and chemistry (whose doctors are shown to have vastly grown), must certainly facilitate invention. And so do the documentation of past work and appropriate new science (reflected in the Abstracts), and all the proliferation of equipment and specialized services which the modern laboratory puts at an inventor's disposal. If he find he needs some cold near absolute 0, or an electron microscope, or a mathematician, or a translator of Russian, they are right at hand for him. If the contribution of these assistants, who increased during 1921–54 from 35 to 180 per 100 professional scientists and inventors, had been included, our graph would have been still steeper.

[83] It seems probably significant that the Abstracts, our only measure of inventive *output*, the rest being measures of input, have risen less steeply than the other criteria (following the dotted line of chart 4 and ¶ 78.5, 79). We found the outputs rising to 105-fold, while the inputs soared to 345-fold, as the somewhat differing slopes show. The very real difference recorded strongly suggests a declining yield from inventive effort.

[84] Further considerations on the meaning of the indexes will be taken up in ¶ 98. In fine, which way the ratio of inventive success to effort may have been changing, still remains somewhat a mystery. But it seems more likely to have declined, as indicated by the steeper slope of our Inputs graph on chart 4.

[85] But is a rise of 345-fold, or 105-fold, in the last 80 years, too much to believe of any large phenomenon? No. Our mere population more than trebled, and the measurable contingent of it which contributes practicably all the inventions, viz., the male whites aged 20–59, has grown to 3.62-fold, leaving 95- or 29-fold to account for ($345 \div 3.62 = 95$). One can find numerous other things that have risen comparably or faster. From 1880 until 1955 only, telephones multiplied 1,160-fold, cigarettes 754-fold, ice cream 4,150-fold, power 16-fold, productivity times workers (cf. chart 1) about 25-fold, secondary education 68-fold.[102] One might object that the greatest growths are in things that hardly existed in 1880—telephones, autos, cigarettes, aluminum—so that our ratios of rise are rather as if we had divided by 0, a procedure forbidden in mathematics. True; but the same swift growth of inventive effort continued through all the later years, not just in starting. Furthermore, invention of the modern, organized, scientific sort, and physical and chemical discovery, are also things that hardly existed in America in 1880. Edison had a small laboratory, and that was all; his good one at Orange was built in 1886, and du Pont's in 1889. Inventing there was in 1880, and patenting, each abundantly, but not through laboratories nor organization, and often not through science, but by the individual ingenuity and informal labors of mechanics, technical men, businessmen, a little handful of

Other calculations by occupations, of the responding 87/122 inventor-patentees, indicated that 75% made the invention as part of their job, and that 67% were technologists and 15% executives, perhaps also technologists, 13% other. He concludes "During the [50-yr.] period invention changed from an activity overwhelmingly dominated by independent individuals to one less overwhelmingly dominated by business enterprise," more than three-fourths of the total, using captive inventors trained in the rising technic professions, whereas the earlier patentees had come from many walks of life. Cf. ¶ 396 ff. later. J. Schmookler: Inventors Past & Pres.: *Rev. of Ec. & Stat.* 39: 321–33, 1957.