large, ungainly volumes. This makes it difficult to obtain a flat copy of the page region closest to the binding. Particularly annoying is the distortion of pictorial information.

It would be very helpful if publishers not unamenable to limited, scholarly reproduction of their material would make the "interior" margins of pages broader, to obviate the problem above. At the least, it would be helpful to place graphs, diagrams, and so on in positions away from the binding, all other things being equal.

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7/17/78

Philosophy of particles

In his article "When is a particle?" (June, page 23) Sidney Drell draws a parallel between discussions concerning whether neutrinos, for a long time individually unobserved, really existed; and quarks, apparently essentially unobservable individually according to present theories. In 1948 S. Dancoff gave an essentially positivistic reply, that the debate was unnecessary as long as the neutrino formed part of theories that gave observable results. This point of view is perhaps best expressed by P.A.M. Dirac when he says: "Only questions about the results of experiments have a real significance and it is only such questions that theoretical physics has to consider."

Even in its heyday there were many varieties of logical positivism. At present few physicists would admit to being logical positivists, but many appear to be still "tainted" by its "legacy" (for example, see Eugene Wigner[1]). In the problem of existence or non-existence of particles it is well to recall the half-humorous proposal of Von Neurath, a prominent member of the Vienna Circle, to compile an *Index Verborum Prohibitorum*, for such words as Existence, Reality, Truth. These words, which have a perfectly clear meaning in ordinary speech, have been taken over by metaphysicians, and have also penetrated into physics, generating more heat than light. In the above question: "Do neutrinos really exist?" can one reply: "Yes, but not really"?

In the latter part of his article, Drell uses the term "observation" rather than "existence." While this term has been subjected to philosophical analysis (Pierre Duhem[2] already started this), it has a much clearer meaning for most of us.

In my opinion,[3] the clearest "positivistic" view of physical theory is given by contemporary model theory, essentially a form of instrumentalism.

As to whether particles smaller than quarks shall be observed or introduced into more sophisticated theories, only the future can tell, which seems to be the main conclusion of Drell's article. Perhaps even the concept of "elementary particle" will be discarded, and continuum theories will take its place, unlikely as it seems at present.

References

1. E. P. Wigner, in *Proc. of the International School of Physics "Enrico Fermi,"* Course 49, Academic, N.Y. (1971), page 123, where Wigner says: "For a positivist (as most of us are)..."
2. P. Duhem, *The Aim and Structure of Physical Theory*, 1st ed. Paris (1906). Duhem asserts that any observation is only meaningful in terms of some theory (paradigm?) held by the observer.
3. A. V. Bushkovitch, Philosophy of Science, **41**, 1, 86 (1974); also International Logic Review, **8**, 23 (1977).

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Elsasser's memoirs

The review of my memoirs by Paul Hanle (August, page 55) misconstrues the intent of my book. It was written to show the historical background, the social and intellectual ambience, and the more human aspects of science in a great period of physics, with my personal experiences serving as the main connecting thread. The reviewer's standards seem to ask a lot of me: He is unhappy that, apparently, I "cannot advance [my] own achievements," and he thinks of my more detached attitude as implying "self-contempt." Because I have resorted to psychological arguments on occasion it does not follow that I can or even should indulge in character analysis of prominent physicists, as he seems to demand. He says that my early "achievement was much in spite of the social and physics environments." The "social" is largely true since my young manhood coincided with the growth of Nazidom, but addition of the "physics environment" seems an embellishment by the reviewer.

With respect to those physicists I have encountered he says that I have "drawn several dozen sketches . . ., most only a page or two of summary." Here are the names of those physicists to whom I devote an aggregate of about three pages each: Sommerfeld, Heisenberg, Einstein, Born, von Neumann, H. A. Lorentz, Pauli, von Laue, Wigner, Bethe; in addition five pages for Millikan. Oppenheimer occurs frequently, adding up to over six pages. There are seven pages for Schrödinger and seven pages for the Joliot-Curie couple, all of these from the scientific viewpoint together with personal recollections, and that in 260 pages (not 216 as the review says).

Again, I must protest the reviewer's distortion of history when he says: "Nuclear physics was born, at almost the

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same time as the Third Reich, out of the discovery of the neutron." The early development of nuclear physics was brought about by three remarkable people: Rutherford and the two Curies. I have well known the next generation of French explorers, the Joliot-Curies and describe them at length. And I quote a pupil of Rutherford's, P.M.S. Blackett, himself a famous nuclear physicist, saying about Joliot that if it had not been for the Second World War "there can be no doubt that the first functioning nuclear reactor would have come into existence in France."

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Encouraging innovation

The excellent editorial on innovation by Jack Goldman of Xerox in August (page 88), prompts me to mention a technique used by Singer, Link Division (Binghamton, N.Y.) which I consider useful in encouraging their engineers and scientists to be more innovative. The following two paragraphs are from a letter of J. Rothenberg, their Director of Patents:

"Inventors Recognition Weekend—An annual function offered to employees to whom a patent issues in the previous year. These employees, and their spouses, are guests of the Division at a resort hotel where they participate in a special program to encourage further innovation. The program generally includes a speech by an authority in the field of inventions and/or patents, an informal brainstorming session, and an awards banquet. In addition, the Weekend provides a unique opportunity for creative employees from all operations of the Division to meet and interrelate and for the Division's management and Patent staff to establish stronger bonds with those engineers who have demonstrated an ability to successfully invent."

"The Division benefits from the Patent Awareness and Incentive Program by way of increased innovation, improved employee morale, prompt disclosure of new ideas and full cooperation with the Patent Department. Needless to say, invention and the protection of such invention is a critical factor in maintaining Singer's position of leadership in the highly competitive simulation business."

Prior speakers have included Jack Rabinow, and this year, because of the publication of my latest book, *The Creative Engineer* (Plenum) (see page 62 in August), I was asked to address the group and to participate in the brainstorming session. The presence of wives is helpful because they encourage their husbands to invent *again* so as to be invited to another resort hotel weekend!

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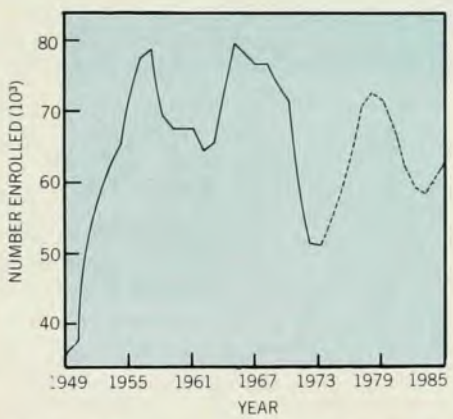
PhD production cycle

In a recent book[1] R. B. Freeman shows that engineering freshman college enrollments went through two minima between the early 1950's and the early 1970's and predicts that another minimum will occur by the early to late 1980's (see figure 1). Of course, the reason for the oscillations is that the system has long response lag times to stimuli.

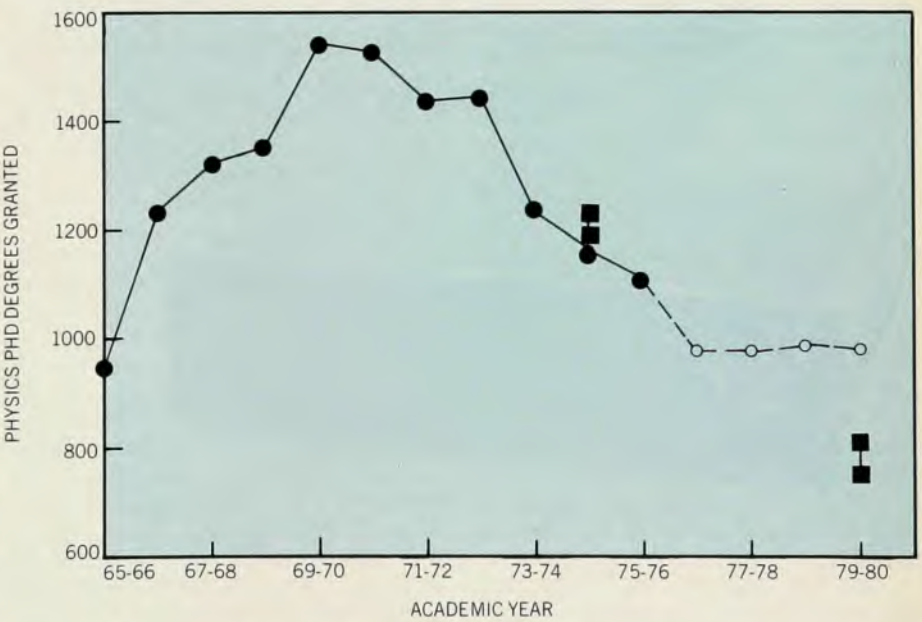


Freshman engineering enrollment from R. B. Freeman (ref. 1); dashed curve is projection by Freeman for years after 1973. Figure 1

our bachelor-degree and masters-degree graduates in meaningful employment. In a paper[2] Freeman claims that the number of physics PhD degrees has shown (see figure 1 of Freeman's paper) and will continue to show a cyclic behavior. Freeman's predictions for physics PhD degrees to be granted in 1975 and 1980 are shown in figure 2, along with AIP data and projections. It appears that, if Freeman's and AIP's projections are reasonably correct, the physics PhD production cycle will have a longer period than does the engineering freshman enrollment, which appears reasonable since the former system has longer response lag times than does the latter. Comparing figure 2 here with figure 1 in Freeman's paper, one arrives at a period of fifteen years or longer.

Note that Freeman's projection for physics PhD's to be granted in 1980 is about 20% lower than the AIP projection. I hope that physics manpower experts will study carefully the different projection methods used by AIP and by Freeman and analyze them for us in future issues of PHYSICS TODAY. Also, I would like to see initiation of and a striving to maintain a continuing dialog in PHYSICS TODAY concerning the following questions on this subject:

- Will physics PhD degrees again overshoot the demand in the next decade, given the system as it now exists?
- Are there any changes we can make in the system that will dampen the oscillations?
- Is it desirable to make such changes in the system?



Physics PhD degrees granted as function of academic year. Solid circles are AIP data (ref. 3), open circles are AIP projections, and squares are projections by Freeman (ref. 2). Figure 2

In physics our main concern with cycles of degree production is at the PhD level; we seem to have little difficulty in placing

References

1. R. B. Freeman, *The Overeducated American*, Academic, New York (1976).