suppressed; he must certainly have sold more books than any physicist or astronomer, and must be one of the best-read authors of all time.

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10/2/78 *Los Angeles, California*

Breakdown in innovation

The breakdown of US innovation has been discussed quite often recently (August editorial, page 88). In addition to the usual prescriptions of technological push, commitment to basic research, and so on, may I reiterate an old buzz word—government bureaucracy. We have all heard that the average application to FDA for approval of a new drug is not counted in pages or volumes, but is weighed in tons. It is beyond imagination how much R&D time, effort and money would be really spent in filling out (and also in reading) the tons of application forms. There are other aspects that may also be detrimental to innovation.

It is not often realized that innovation and risk may be regarded as complementary variables in the Heisenberg uncertainty principle. The bigger the innovation, the bigger the risk. We tend to remember the success stories and often forget the failures. In the decade following the Bohr atom, the list of famous physicists who worked on quantum mechanics is far longer than the few names that we remember today. Under present conditions, successful innovation brings only modest reward (for example, promotion from GS-13 or 14 to 16 or 17 or 18, a 20% salary raise), but a failure would mean a catastrophically ruined career. It is usually much safer to adhere to the established research program. But then it can be argued that an overly rigid program can lead to obsoleteness or a tendency to solve the same old problem on a slightly bigger computer for a slightly more accurate answer (May, page 15).

In addition, there is the unwritten but widely believed dogma that scientific creativity declines rapidly after the age thirty. As a corollary, research directors and personnel managers are reluctant to hire scientists older than thirty. With high unemployment in physics (9% in 1974, 13% in 1975), it follows that only scientists younger than thirty can risk any possible failure. Unfortunately, the average age for receiving the PhD degree is in the late twenties.

The bureaucracy and the rigidity tend to produce fashionable research rather than innovative research. Take the war on cancer as an example. We have seen the ever-changing emphasis on radiation therapy, chemotherapy, virus origin of cancer, immunotherapy, and the current fad of environmental origin including hamburgers. In other words, everything except a cure. It is probably not surprising that the war on cancer has now become known as the medical Vietnam.

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PRL versus *JETP*

Physical Review Letters is internationally recognized as the most prestigious physical journal. This means great honor and implies great responsibility.

PRL is devoted to "containing short communications dealing with important new discoveries or topics of high current interest in rapidly *changing* fields of research," obviously, no matter where such a paper comes from.

Let us analyze from this viewpoint the publications in arbitrarily chosen volume 40 of *PRL*. It contains 512 papers; only 133, that is 26% of the accepted papers, are not related to an American author or institution, and come from Europe, Japan, Canada, Australia and the rest of the world. Of course, the scientific importance of the institution influences the importance of the publication. However, the reverse may also be true.

If we look, for simplicity, only at the month when *PRL* is published and when a paper was received, the number of papers versus the time before publication is as follows:

Time (months)	1	2	3	4	5	6	7	8	9	10	11	12
Number of papers	16	131	147	88	63	28	16	10	2	3	3	3

The average time-lag is about 3.5 months; a quarter of all papers wait half a year on average before they are published! Assuming that they also meet *PRL* criteria of importance, do they meet the criteria of urgent publication?

The Soviet journal that corresponds to *PRL* is *JETP Letters*. For its (also randomly chosen) 23rd volume (in the AIP edition) the figures are the following

Time (months)	1	2	3	4	5
Number of papers	72	99	1	1	1

The average time-lag is just 1.5 months, that is less than half that of *PRL*! Only 1.7% of papers wait more than three months, only 0.5% wait five months; none of the papers wait longer.

This may be related to the system of refereeing in *JETP Letters*, which is therefore of some interest. As an author and referee of the *JETP Letters* and *JETP* for 20 years, I should like to describe it. The names of referees (2 for *JETP* papers) are confidential, as they are for *PRL* and *PR*. The referee receives a small honorarium. The referee of the *JETP* is advised to submit his comments to the journal within 10 days or else to return the paper to *JETP*. If the comments are not received within the indicated time (usually because the referee is absent), the paper is sent to another referee. The referee rejects the paper *only* if it is not novel, or if it is trivial, or wrong. In each case he must be quite specific: give the reference to similar results; indicate how the main result, if he considers it trivial, may be easily obtained; indicate the mistake. If he cannot be that explicit, he must suggest that the editors send the paper to a referee who is expert in the field. Naturally, such a criticism is practically always accepted by the author (unless the author can indicate a mistake in the referee's comments) and precludes further correspondence. When the paper is novel and the referee sees no mistakes in it, but is unhappy with the style or the presentation, he recommends the publication of the paper, if certain places in it are revised according to his suggestions. After the revision, the paper is sent back to the same referee for his new comments. Typically this takes very little time. A misunderstanding between the referee and the author is very unusual.

It seems to me that, however high a journal's criteria, specificity of the referee's comments and distinction between the scientific value of the paper and its style may be very helpful both for authors and the journal, and may essentially accelerate publication.

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PRL COMMENTS: We find Mark Azbel's comparisons of *JETP* and *PRL* interesting both as a comparison of journalism and as a comparison of scientific sociology in (largely) the US and Soviet Union. The publication time-lags, which Azbel discusses, can be separated, for *PRL*, into two distributions. For those articles which pass through our selection processes without delay, there is a time lag of a little less than two months between the data the article is received and the time when the journal containing the article is delivered to the subscriber's mailbox. Then there is a highly skewed distribution, which extends almost indefinitely, for those papers (a majority of the accepted papers) which are not approved unconditionally by two referees. It seems that the *JETP* is quicker than we are by nearly a month on immediate acceptances and the second set, the set of papers which

are accepted only after considerable negotiation and considerable modification of the manuscript, hardly exist in Russia.

The minimum time of almost two months required for us to place an accepted manuscript in the reader's hands, is set by editorial time requirements, United States Post Office transfer times, delays in the response of the referees and our own manuscript preparations and printing times. These times can be reduced substantially only by increasing our costs—and our page charges—significantly and we choose not to do so. We will then have to bow to our Soviet colleagues' superiority in handling such manuscripts.

The difference in the second groups is more interesting. Our nominal acceptance criteria and mechanisms for establishing those criteria seem to be almost identical to the *JETP* procedures which Azbel describes but it is possible that the compromises required between speed of publication and excellence of presentation are made differently by *PRL* and *JETP*. Indeed we do not believe that fast publication of all papers is really consistent with the excellence of substance and style we attempt to attain for what Azbel so kindly describes as the "most prestigious physical journal."

Are there other differences? We think that a clue to such a difference may lie in Azbel's statement concerning the reception of criticism by *JETP* referees; "Naturally, such a criticism is practically always accepted by the author." For *PRL*, our experience has been almost the opposite; with little hyberbole, we can say that our authors practically *never* accept the criticism of the referee. Why that difference? Are Russian referees more precise and more (or less) responsible? Are Russian authors more acquiescent? Are the editors of *JETP* firmer in their rejections than we are (or can be)?

We do not know the answers to these questions but we suspect that the main cause of the different time lags for the two publications lies in appreciable differences between the expectations of authors, referees and readers of these two, nominally similar, journals.

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GEORGE L. TRIGG
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10/24/78 *Physical Review Letters*

More on proliferation

Your April article on "Nuclear power and nuclear-weapons proliferation" by Ernest Moniz and Thomas Neff (page 42) ignores fundamental deficiencies in US Government antiproliferation policy:

- Overuse of unilateral approaches
- Failure to make sacrifices in military programs
- Overemphasis of the hypothetical role of deverted reactor-grade plutonium
- Inadequate recognition of underlying energy and economic pressures
- Decisions based on misunderstood technology

Recently J. S. Nye, who was chairman of the Group on Nonproliferation within the National Security Council, wrote an article, "Nonproliferation: A Long-term Strategy," [1] that contained only one paragraph and a few sentences (out of 22 pages) addressing the influence of the nuclear arms race upon horizontal proliferation. It should also be noted that the Non-Proliferation Act of 1978 fails entirely to relieve proliferation pressure attributable to military nuclear-weapons programs. None of these US Government positions calls for cessation of nuclear-weapons testing, no-first-use of nuclear weapons, or the establishment of nuclear-weapons-free zones.

As long as the weapon-states are unable to reach accord, the primary driving force behind horizontal proliferation (to more nations) will be the continued vertical proliferation (arms-race).

Besides avoiding these proliferation factors above, the evaluation by Moniz and Neff does not take into account possible theft or clandestine transfer of completed weapons or fissile material from nuclear-weapons states as a result of ongoing military production; nor do they give adequate weight to capabilities of nations to build secret installations.

The authors have been misinformed about the inherent degree of resistance afforded by a denatured thorium cycle. It is often stated that, by diluting U^{233} fissile feed with U^{238}, plutonium production will be "substantially reduced" compared to a uranium-cycle reactor. Because of unshielding of the resonances in U^{238}, only a factor of three reduction is likely; this could still allow, in theory, about 14 low-quality weapons to be made per year from the plutonium of a 1 GWe denatured thorium reactor. In addition, the large isotopic difference with U^{238} makes U^{233} relatively easy to separate in a few centrifuge stages. What has also been overlooked is that Th^{232} nuclei that capture neutrons dwell as Pa^{233}, with half-life of about one month, before decaying to U^{233}. Thus, by *chemical* means the Pa^{233} can be separated from the fuel before it is isotopically denatured by the U^{238}; this will produce enough U^{233} to make about 10 weapons-grade critical masses per GWe yr.

It should be kept in mind that U^{233} has better weapons potential than either U^{235} or plutonium, critical mass much less than U^{235}, higher and more dependable explosive-yield than any reactor-grade of plutonium, and is adaptable to either implosion or gun-barrel fission-explosive design because of the absence of inherent spontaneous neutrons that characterize plutonium.

Because several weeks to a month must transpire before enough U^{233} can be milked from Pa^{233}, it can be said that denatured thorium-cycle reactors are more secure against certain forms of diversion than once-through U-cycle reactors. However, in terms of ultimate production of weapons-grade material, a thorium-cycle would be attractive to a government that is hedging for a long-term supply of fissile material to be used to make weapons.

The preceding remarks are often misunderstood to suggest that fissile materials can be easily siphoned from any nuclear fuel cycle. Because of high radiation fields, full-scope safeguards, and an interwoven net of institutional and technological measures, there is a high degree of inherent security associated with the commercial fuel cycle. All irradiated fuel has considerable self-protection against diversion; appropriate collocation, coprocessing and safeguards can provide physical security for the remainder of the fuel cycle.

Another item of technical misinformation repeated by Moniz and Neff is the idea that uranium "... can be isotopically denatured, [plutonium] can not." The situation is far more complicated. Plutonium containing a large fraction of even isotopes has a critical mass at least an order of magnitude larger than pure Pu^{239}. Although it is impossible for an explosion to occur, the yield/weight ratio for isotopically-denatured plutonium can be many orders of magnitude less than for weapons-grade materials. In particular, the spontaneous neutron rates, the heat production, and the radiation effects of Pu^{236}, Pu^{238}, Pu^{240} and Pu^{242} are such that "complicating weapons design" is a serious understatement when attempting to describe the impact of retaining the even isotopes.[3]

Elsewhere,[2] a means of producing isotopically denatured plutonium has been reported. It can be done in any type of reactor, as long as recycled plutonium is segregated from U^{238} during irradiation.

Calculations indicate that in five or ten years enough plutonium denaturant can be produced to prespike reactors intended for export to sensitive nonnuclear-weapons states. These are the countries where the maximum antiproliferation measures must be applied.

Thus, without going into details, there is another role for plutonium recycle: namely to produce isotopically denatured plutonium, a nuclear fuel component not practical for military or paramilitary (terrorist) weapons.

The competitive, economic, and national-security implications of assured fuel supplies, including fissile plutonium, cannot be overlooked. Inflationary pressures are arising from the huge balance-of-payments deficit due to oil imports. There is growing realization that the true occupational-health, social and