

## STM not developed in a vacuum

Calvin Quate's article "Vacuum tunneling: A new technique for microscopy" (August, page 26) properly calls attention to a developing technology that promises new and more detailed knowledge on an atomic level of the physical and electronic properties of surfaces. [See the news story on page 17.] Sadly, the article contains historical inaccuracies, distortions and omissions that will help perpetuate the public's ignorance of the actual evolution of the scanning tunneling microscope.

It is only recently that the pioneering work of Russell Young at the National Bureau of Standards throughout the late 1960s and early 1970s has begun to gain a bit of the recognition it so justly deserves. Unfortunately, Quate's article fails to reflect the realities accurately. Two quotes illustrate the point: "The scanning tunneling microscope had its beginnings in Frankfurt in 1978, in a conversation between [Heinrich] Rohrer and [Gerd] Binnig," and "Young discussed vacuum tunneling in his *PHYSICS TODAY* article [November 1971, page 42], but did not pursue the subject in his technical publications." In fact, two fundamental papers published by Young (*Physical Review Letters* 27, 922, 1971, and *Review of Scientific Instruments* 43, 999, 1972) invalidate both of these claims. Neither paper was referred to by Quate.

The *RSI* article reported topographic maps of a diffraction grating replica, obtained using an instrument essentially identical to the present-day STM. The *Physical Review* letter reported the first vacuum tunneling measurements, made using this same instrument. (Quate seems to have inverted the roles of Young and Clayton Teague, who came to NBS to do a doctoral thesis with Young using Young's instrument.) Both the NBS instrument, called the "topografiner," and the STM employ two orthogonal piezoelectric elements to scan in a raster a sharp emitter above a conducting surface while a third,  $z$  piezo follows the profile of the

surface. Both instruments amplify and feed back to the  $z$  piezo the current changes at fixed emitter voltage (or voltage changes at fixed emitter current) so that the emitter is scanned at a constant distance above the surface. The  $z$  piezo voltage is then a measure of the surface topography. Both the topografiner and the early STM papers predicted sub-angstrom vertical resolution and 50–100-Å horizontal resolution, depending on the emitter radius.

The topografiner reported in 1972 was a prototype instrument with elementary vibration control and no provision for repositioning the specimen. Although excessive vibration prevented scanning in the tunneling mode, static current versus voltage curves for several fixed spacings were reported that displayed, as the spacing was decreased, the evolution from field-emission tunneling to the linear current-voltage characteristic required to verify metal-vacuum-metal tunneling. Many of us associated with Young at the time were extremely disappointed when in 1972 the development of the instrument was terminated by a management decision to redirect effort into a new program in micromasurements in response to the calibration needs of the microcircuit industry.

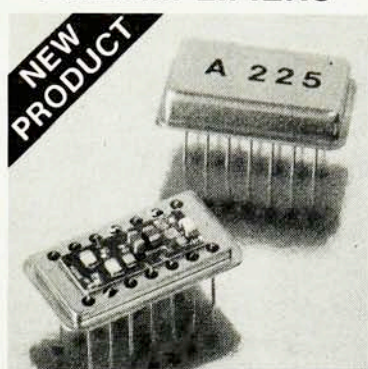
All of the above is in no way intended to minimize the outstanding contributions of Binnig and Rohrer, who first demonstrated atomic resolution in a scanning device and who went on to apply the instrument to a number of significant surface problems.

J. WILLIAM GADZUK  
National Bureau of Standards  
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## SDI: Subs, space and smuggling

In defending his book *How to Make Nuclear Weapons Obsolete*, Robert Jastrow (January 1986, page 9) notes that all of Richard Garwin's errors are in one direction—they make strategic defense against Soviet missiles seem costly and ineffective. No one can make

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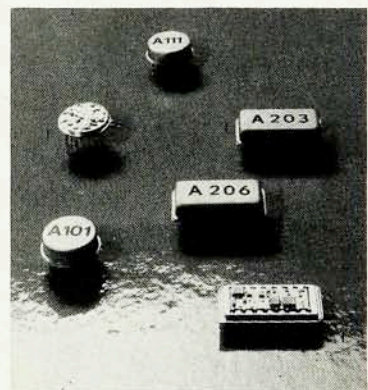
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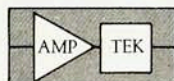
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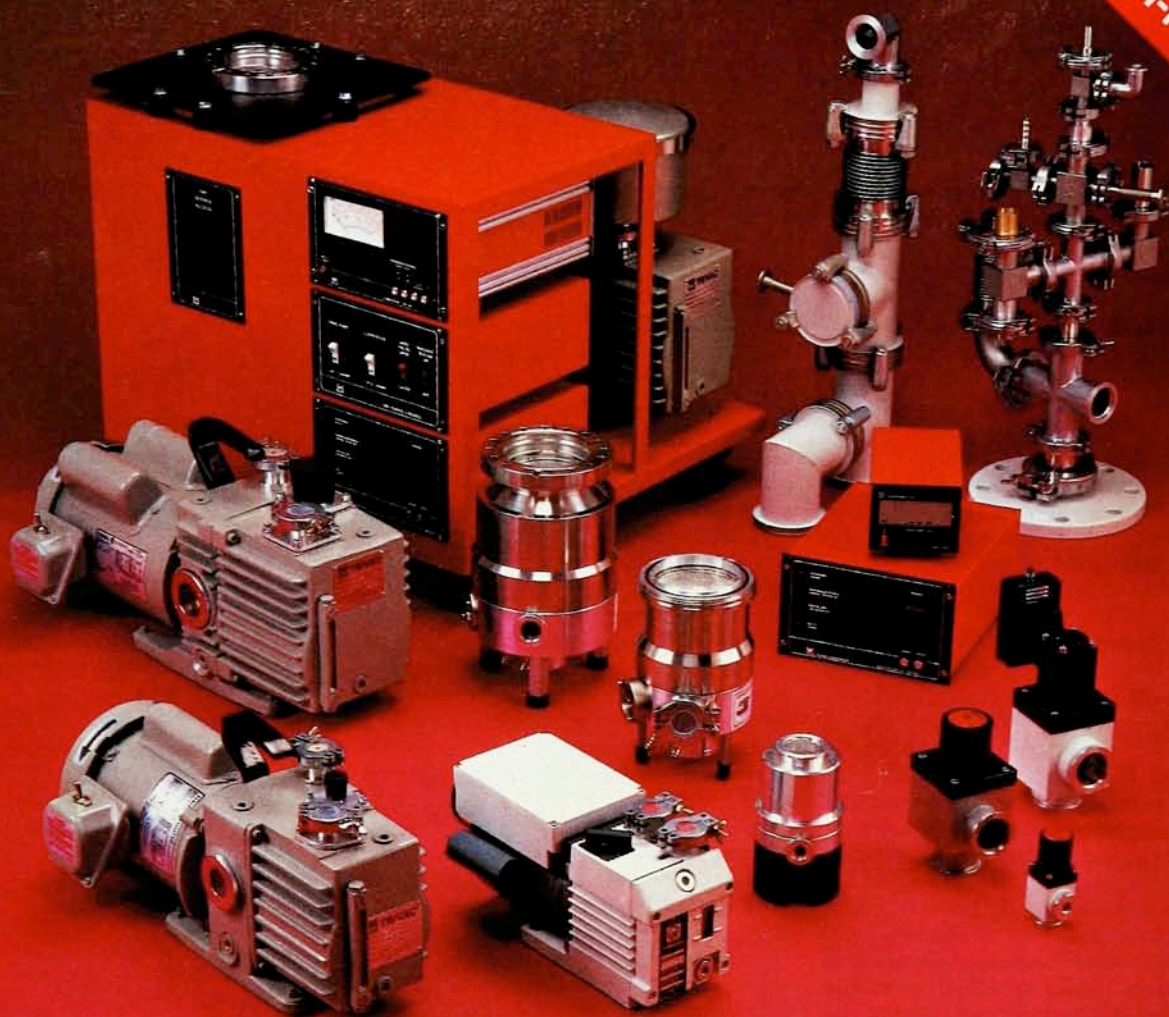
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## letters

the same accusation about Jastrow, for he errs in two directions. He consistently overestimates the current and near-term Soviet threat while consistently underestimating the Soviets' ability to overcome our defenses.

For example, Jastrow writes that "at some point in the future, possibly in the next decade, ballistic missile submarines will lose their invisibility." It is possible that our submarines may become vulnerable someday, but it is not likely to happen as soon as Jastrow fears. A recent CIA report states,<sup>1</sup> "We do not believe there is a realistic possibility that the Soviets will be able to deploy in the 1990s a system that could pose any significant threat to US SSBNs [nuclear powered ballistic missile submarines] on patrol." The CIA report should not be misinterpreted as meaning that the Soviets are likely to develop an effective submarine defense in the year 2001 or 2010 or 2020. It is simply too soon to tell when, if ever, submarine defenses will be built.

Let us assume, however, that our submarines will become vulnerable. How will this affect deployment of the hydrogen bomb-pumped x-ray laser, which, according to Jastrow,<sup>2</sup> "holds the promise of being a devastatingly effective destroyer of missiles"? The laser's small size will allow us to place it on a missile and pop it up when we detect a Soviet attack. By putting our lasers on missiles instead of satellites we can ensure that the Soviets will not be able to use their antisatellite weapons to launch a preemptive attack against them. There is, however, one problem with pop-up lasers: The missiles carrying them must be based near the Soviet Union. Otherwise they will not be able to reach sufficient height to target the Soviet missiles during boost phase because their line of fire will be blocked by the curvature of the Earth. Therefore, they will probably be placed on submarines patrolling near Soviet shores. But if our submarines become visible to Soviet satellites they will be especially vulnerable patrolling near the Soviet Union, where they will be only a few minutes' flight time from Soviet missiles.

The SDI Organization has recently decided to increase its funding for H-bomb-pumped x-ray laser research despite funding restrictions that have forced significant cuts in other programs such as the space based chemical laser. The x-ray laser's increased priority indicates one of four possibilities concerning the leaders of the SDI Organization:

► They do not really believe that our submarines will become vulnerable.

This is the most likely explanation. Lowell Wood, head of the group working on x-ray lasers at Lawrence Livermore National Laboratory, told<sup>3</sup> *New York Times* reporter William Broad, "The most attractive locations for x-ray laser platforms are probably submarines, for vulnerability reasons."

► They are incompetent morons who have not thought out the consequences of our submarines' becoming vulnerable.

► They have allowed bureaucratic politics rather than national security to decide which programs should be funded. Jastrow should be calling for the dismissal of SDI chief General James Abrahamson if he believes this is the case.

► They have abandoned the idea of the pop-up laser as totally illogical. This would still allow them to place the lasers in orbit, but that would be politically unpopular and would violate the Outer Space Treaty, and in any case, if we put nuclear weapons in space the Soviets will follow suit.

Let's assume that Jastrow is correct when he states that we will gain the ability to lift objects into orbit for tens of dollars a pound. If the Soviets gain similar capabilities they could place tens of thousands of nuclear bombs in orbit. This could be fatal to strategic defenses. As Jastrow states:<sup>4</sup>

We would have very little warning of an attack by a bomb in orbit—even less than in an ICBM attack—because when the Soviet commander sends the radio signal to the satellite to brake its motion and drop its bomb to the Earth, only three or four minutes elapse before the bomb hits the surface.

Jastrow states in his letter that "sleeper" or spare satellites and decoys can help protect our satellites. How can this be? If we assume that the US will have sensors capable of discriminating thousands of warheads from tens of thousands of decoys in less than half an hour, we must assume that the Soviets will have sensors capable of discriminating satellites from decoys after months of observation. Because the Soviets will only have to punch a hole through that part of the satellite network which is over their country during their attack, we will need spare satellites spread throughout the network to insure that there are enough over the Soviet Union to replace those destroyed in battle. Perhaps doubling the number of satellites would provide the required margin of safety. But this would not be a cost effective way of establishing satellite survivability. Suppose it paid for the Soviets to build enough ground based lasers (or any other ASAT device) to

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## letters

destroy a small part of the original satellite network. If we doubled the number of satellites in our network, the Soviets could double the number of lasers aimed at our satellites.

It only takes a little thought to render Jastrow's arguments obsolete. Doing the same to nuclear weapons will be much harder.

### References

1. *Soviet Strategic Force Developments*, CIA National Intelligence Estimate (26 June 1985), p. 6.
2. R. Jastrow, *Commentary*, March 1985, p. 17.
3. W. J. Broad, *Star Warriors*, Simon and Schuster, New York (1985), p. 159.
4. R. Jastrow, *How to Make Nuclear Weapons Obsolete*, Little, Brown, Boston (1985), p. 60.

ROBIN S. MESSING  
Ithaca, New York

6/86

JASTROW REPLIES: Robin Messing makes several interesting points. I would like to bypass his remarks on the x-ray laser, because the United States is committed for the present to a non-nuclear defense and the x-ray laser will not be among the first defenses to be deployed unless the Soviets force our hand with their own program in this area.

In fact, according to the way SDI research has been going, the first defenses to be deployed will not include lasers of any sort. They will depend on "smart bullets" or kinetic energy weapons—upgraded versions of the proven heat seeking air defense missile in operational use for years.

Taking Messing's other points in order: He is on solid ground in citing the near-invulnerability of today's US ballistic missile submarines. Indeed, *How to Make Nuclear Weapons Obsolete* states, "Submarines on station are essentially undetectable."

The aspect of this situation, however, that disturbs me and others, and was noted in my book, is that the submarine is the only remaining leg of our deterrent triad that still has this degree of invulnerability. Our land based missiles have been compromised by Soviet SS-18s; it is generally agreed that very few Minuteman ICBMs would survive an SS-18 attack. The air based leg of the US triad has also been compromised by the massive Soviet air defense build-up. As a result, American protection from nuclear attack is largely dependent on the invulnerability of that one remaining leg of the triad—the ballistic missile submarine.

Navy sources stoutly maintain that this invulnerability will persist into the

indefinite future, but other defense planners are less optimistic. They note that Soviet nuclear tipped SA-12 missiles are mobile and can therefore be placed on Soviet ships and deployed against our submarine launched ballistic missiles in the boost phase. Nuclear tipped SA-12s have the promise of being a very effective defense against our SLBMs, and one to which the United States at present appears to have no response.

Other uses of small nuclear weapons in antisubmarine warfare are also possible. As I noted in my January 1986 letter, a senior Pentagon official publicly stated last year, "It is a matter of time before our confidence in the invulnerability of the submarine leg is degraded." This is the first time, to my knowledge, that the Pentagon has publicly admitted this fact.

The essence of the matter is that right now the submarine is the single thread by which American security is suspended. Messing is confident that this thread will not snap in the foreseeable future. He may or may not be right. If he is wrong, catastrophic consequences will follow. Prudence requires that we protect ourselves against that eventuality.

Regarding bombs in orbit: The Soviets apparently conducted tests of this technique in the 1960s. The tests are mentioned in *How to Make Nuclear Weapons Obsolete* as an example of Soviet willingness to go far beyond the United States in the introduction of offensive weapons into space. However, as far as we know, the Soviets abandoned their efforts permanently after a few years.

One can easily see why, considering the problems the Soviets have had in preventing the radar ocean reconnaissance satellites, with their nuclear power supplies, from spiraling out of orbit over inhabited areas. I would guess that even the Soviets were daunted by the potential for nuclear disaster inherent in that fleet of "tens of thousands of nuclear bombs in orbit" that Messing suggests so casually as a Soviet option.

Regarding satellite survivability: The main threat to our early space defenses will be the nuclear tipped intercepting missiles now being installed around Moscow as part of a new Soviet ABM system. When a launch of one of these Soviet interceptors is detected, decoy satellites can be thrown out in response to that threat. They need not be in orbit beforehand, available for leisurely inspection and targeting by Soviet sensors, as Messing suggests.

While quick deployment of decoy

continued on page 108

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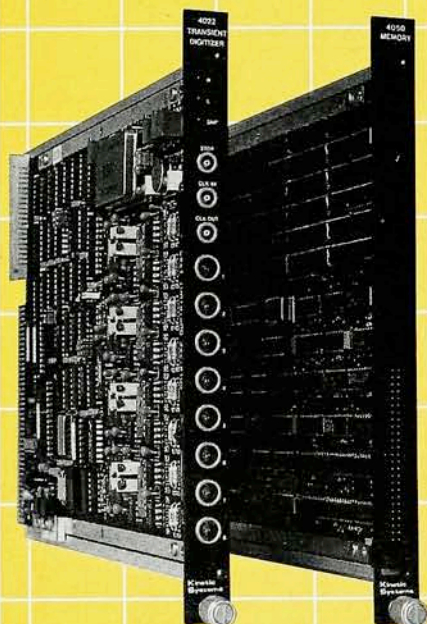
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## letters

continued from page 15

satellites will be a useful US stratagem for enhancing space survivability, the main US response to the threat posed by the Soviet intercepting missiles is likely to be the "shoot-back." That is, the smart bullets, or homing interceptors, carried on US weapons satellites as the main component of our boost phase defense against a Soviet attack will also be used to defend the weapons satellites themselves.

Ground based laser ASATs are another potential Soviet threat to our space assets, although one that will probably not mature until late in the 1990s. One response to the laser ASAT is satellite shielding sufficiently thick to parry the initial Soviet laser attack, although perhaps not thick enough to protect a satellite from a sustained Soviet laser assault. But that initial Soviet attack on our space assets would be an act of war, comparable to an attack on our ships at sea. It would indicate Soviet intent to initiate a major nuclear conflict. As soon as the attack commenced, the US would be justified in instituting countermeasures up to and including destruction of the Soviet laser facility.

ROBERT JASTROW

Dartmouth College

Hanover, New Hampshire

12/86

The letters of Gordon McClure and Thornton Page in the February issue of *PHYSICS TODAY* (page 96) resemble each other in the way they attack the Strategic Defense Initiative with questions that range all the way from profound to shallow to irrelevant. Gordon McClure, for instance, disparages the "contract-hungry scientists, engineers and corporations" that work on SDI. Rational discussions of SDI should not include disparagements of the participants.

Both writers are evidently concerned with the important question of whether defensive strategies ever succeed. History indeed shows that at times defensive strategies can help to win wars. Perhaps one of the best examples this century was the Soviet defense of Stalingrad, which eliminated Hitler's prospects of winning World War II. Other examples include the Israeli defensive success against the Egyptians in the Yom Kippur War of 1973 and the stunning 16th-century defensive victory of the badly outnumbered Knights of Malta against the Turkish attack on Malta.

Another interesting issue raised by both writers is whether cruise missiles,

suitcase bombs and other methods could render a working SDI system useless. These are two extremely different methods of delivering nuclear weapons. Defense against cruise missiles and other "orthodox" military methods of nuclear weapons delivery would have to be included with an SDI deployment; the reason for starting SDI on the ballistic missile problem is that it threatens the most destruction and is technically the toughest problem to solve. With respect to unorthodox delivery of nuclear weapons, I don't think we know how to ensure ourselves against such attacks, but I also don't believe that a Soviet military planner would seriously contemplate using these devices because control of when and where they might be detonated would be so uncertain.

Both McClure and Page present ideas and questions that are way off the subject. For instance, McClure proposes the establishment by the government of an independent agency with funding equal to SDI whose purpose would be to attack the program. This notion would create chaos; imagine if every mission-oriented agency in the US government had to contend with an adversary also funded by the US government. How could we conduct any controversial program coherently under such circumstances? Could a State Department and an anti-State Department ever come to terms on how to deal with the Middle East or with Central American instabilities?

Page narrows his field of view excessively when he raises the question of whether military activities in space such as SDI would help or hinder space science activities that are planned for the next few years. Who would seriously need to think twice when confronted with the choice between ridding the world of a substantial amount of nuclear terror and continuing space science research unimpeded? Page's narrow preoccupation with space science continues with his final suggestion that taxpayers contribute a trillion dollars to colonize the Moon and Mars.

The Strategic Defense Initiative has certainly captured the attention and imagination of readers of *PHYSICS TODAY*. I wish that this attention would be subjected to the same rigorous and disciplined thinking that physicists apply to their usual professional pursuits.

MARVIN KING

Riverside Research Institute

New York, New York

3/86

McCLURE REPLIES: Contrary to Marvin King's assertion, I expressed no concern about whether defensive strategies ever succeed. That is a straw man. Sometimes such strategies succeed, as

King aptly illustrates, and sometimes they fail miserably, as in the case of the famed Maginot Line. I deem it a worthy objective to avoid such failures, especially in systems that may cost a trillion dollars a try.

King doesn't believe that "a Soviet planner would seriously contemplate using [smuggled nuclear weapons to circumvent a ballistic missile defense] because control of when and where they might be detonated would be so uncertain." A very sound smuggled-nuclear-weapons system would have technical problems and costs; however, I feel that both kinds of obstacle would be small compared with those of a large-scale missile defense. I had in mind a strategically decisive set of hidden smuggled nuclear weapons targeted against a critical lifeline of the US, such as our 280 oil refineries. The weapons would be small nuclear warheads—perhaps 10 kilotons—hidden in peacetime, delivered in automobiles at a signal and detonated simultaneously. I believe this system and its variants deserve very careful study. It appears to be a possible cheap and effective Soviet answer to a putative US nuclear first strike under cover of a space weapons shield.

I have given up my earlier idea of establishing an independent government agency to study possible negative aspects of a deployed ballistic missile defense. An agency such as I suggested would probably be worthless because it would be subject to the same debilitating political constraints of unsympathetic Presidential Administrations as is the present Arms Control and Disarmament Agency. A free press, privately funded research centers and a concerned, informed citizenry remain the only apparent mechanisms to forestall ill-conceived systems such as ballistic missile defenses. Early public access to military plans is essential to the effective functioning of these legitimate public-rooted adversarial forces.

Because different people's perceptions of the need for military systems of particular types are conditioned by their individual views of who the "enemy" is, what the enemy might contemplate as its world objectives, what the enemy's weapons systems might be able to do and what the enemy might do in response to our new weapons initiatives, these perceptions will remain forever inaccessible to the kind of "rigorous and disciplined thinking that physicists apply to their usual professional pursuits." These matters are inherently subjective. Physicists can play an important role in the debate only to the extent that they ponder the subjective matters to which I allude, read the relevant literature and use



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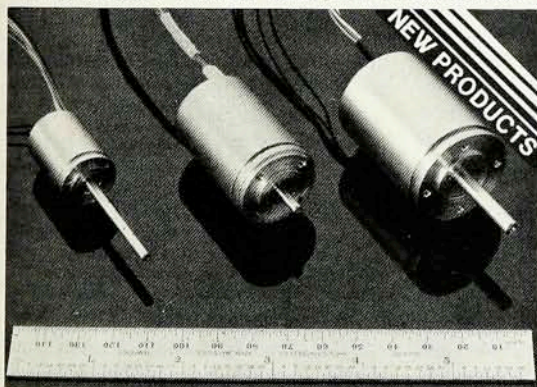
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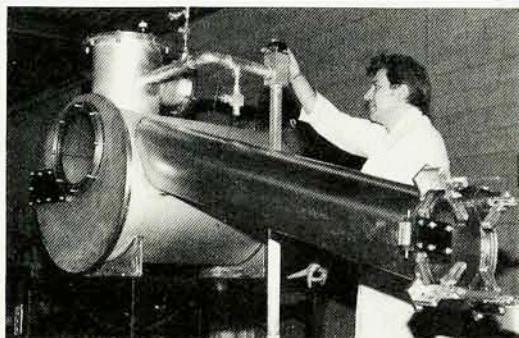
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109



## letters

their consciences to decide which weapons systems they will help build.

GORDON W. MCCLURE  
10/86 Albuquerque, New Mexico

PAGE REPLIES: Marvin King is obviously dedicated to SDI whether it can work or not. As for my "narrow field of view," I am sure that the exploration of space is a good deal "wider" than the futile attempt to shoot down ICBMs when a simpler and much cheaper arrangement is to agree with the USSR to destroy them before they are launched. The Soviets are keen on space exploration; let's cooperate with them on that, save money and achieve something worthwhile.

THORNTON PAGE  
NASA Johnson Space Center  
9/86 Houston, Texas

## Treaties and the Constitution

The letter by J. H. Phillips and the response by Wolfgang K. H. Panofsky (April, page 90) raise interesting issues regarding the relationship between the Federal treaty-making power and the constitutional rights guaranteed by the Bill of Rights. Although both Phillips and Panofsky deal solely with issues arising under the "right of the people to keep and bear arms" provision of the Second Amendment and with alleged infringements of this "right of the people" by arms control treaties, the issues are significantly broader in scope and deserve more careful analysis.

According to Panofsky, the constitutional authority of the executive branch to conduct foreign affairs extends to the power of the President to negotiate arms control treaties, and such treaties when ratified by the Senate may abrogate any provision of the Bill of Rights. Although Phillips disagrees, both Phillips and Panofsky limit their discussion to consideration of the Second Amendment in the Bill of Rights. However, there is nothing in the underlying issue that should limit the argument to the Second Amendment; rather, the issue should be treated more broadly for a better understanding.

For example, it is not difficult to imagine a treaty with the following provision:

Due to the utmost importance of this arms control treaty and the practical reality that it cannot be successfully implemented without mutual trust and harmonious relationships between the signatory nations, any critical or derogatory

remarks, oral or written, against a signatory shall constitute a criminal offense against that signatory, and such signatory may search for and seize any offending writings, as well as punish the person making said criticism, in such manner as it deems appropriate, including trial by judge without jury in the courts of the signatory as it deems appropriate.

Of course, such a treaty would clearly abrogate the provisions of the Bill of Rights contained in Amendments I (free speech and press), IV (unreasonable search and seizure), V (due process of law), VI (right to counsel) and VII (trial by jury). But in spite of the fact that the constitutionality of treaties that conflict with the Bill of Rights has never been litigated, some obvious conclusions as to how the US Supreme Court would treat this sort of treaty can be drawn.

Moreover, that the precise issue has never been litigated does not justify Panofsky's conclusion that it is "patently absurd" to claim that the treaty-making power cannot supersede the Bill of Rights. It is true that a treaty can override a state constitution or a state statute, but a Federal statute passed at a later date than a treaty prevails over the treaty, according to a line of US Supreme Court cases beginning with *Head Money Cases*, 112 US 580, 598-599 (1884). It is also well established that even Federal statutes violative of the Bill of Rights can be declared null and void by the judiciary. Thus, since Federal statutes can abrogate treaties, statutes have at least as high a dignity as treaties, and since statutes violative of the Bill of Rights can be invalidated by our courts, so can treaties.

Panofsky's conclusion that arms control treaties can abrogate the Bill of Rights is thus, fortunately for America, clearly unwarranted.

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RICHARD DAVID LAUMANN  
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5/86

PANOFSKY REPLIES: David I. Caplan and Richard David Laumann state that "according to Panofsky the constitutional authority of the executive branch to conduct foreign affairs extends to the power of the President to negotiate arms control treaties and such treaties when ratified by the Senate may abrogate any provision of the Bill of Rights" (italics mine).

My response in the April issue said no such thing. I stated, "According to Article VI of the Constitution, treaties are the supreme law of the land, subject only to other provisions of the Constitu-

tion." In other words, I clearly stated that treaties do not preempt the Bill of Rights. Thus the letter by Caplan and Laumann is attacking a statement that I did not make.

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## Science adviser's role

Let us hope that the damage George Keyworth has done to the role of White House science adviser will be short-lived. As Irwin Goodwin's interview (February, page 57) made clear, Keyworth has transformed this role from giving advice to the President to selling the President's programs to the scientific community, from providing technical information to politicians to purveying political propaganda to technicians.

The problem is not so much the creation of this new role as the loss of the old one. If anything, the President needs sound technical advice now more than ever, and he does not appear to be getting it.

Nothing stands out more here than Keyworth's role in the SDI program; his public statements give no indication that he understands the technical objections to strategic defense, nor has he conveyed any such understanding to the President. As the Reagan Administration continues to pursue this massive, costly program, there appear to be no channels for independent technical criticism to reach the Administration. Keyworth ought to have provided such a channel, and it is to his great discredit that he did not.

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## Who's politicizing physics?

In the October 1985 letters column (page 152) Natan Andrei wrote from Rutgers University that he was to be a member of the American delegation (expenses paid for by NSF) to a February 1985 winter school and international colloquium on exactly solvable problems in condensed matter and relativistic field theories. Andrei complained that he was prevented from attending because the host country "refused me a visa on the grounds of my holding an Israeli passport."

The spokesman who responded for the host institution rejected out of hand the claim that his country "pursues the policy of not granting visas to Israeli passport holders. Such a policy does not exist as far as we are aware; we