"THE BUDDHA SMILES": ABSENT-MINDED PEACEFUL AID AND THE INDIAN BOMB

Roberta Wohlstetter

MONOGRAPH 3

[of Can We Make Nuclear Power Compatible with Limiting the Spread of Nuclear Weapons?
Albert Wohlstetter, et al.,
final report to the
Energy Research and Development Administration,
May 1977]

FINAL REPORT

Contract No.: (49-1)-3747

PH 78-04-370-23

[May 1977; Revised November 1977]

Prepared for

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

Prepared by

PAN HEURISTICS
1801 Avenue of the Stars, Suite 1221
Los Angeles, California 90067

DISCLAIMER

This is one of the final monographs in completion of Phase II of the Energy Research and Development Administration Contract E(49-1)-3747. The scope, depth, comprehensiveness and representation of the views expressed herein reflect solely the judgments of Pan Heuristics. They do not necessarily coincide with, reflect or constitute the official positions of the Energy Research and Development Adminstration, or any other Agency of the United States Government. The staff of Pan Heuristics would like to thank the many officials in the Energy Research and Development Administration, and other Federal Agencies, for the information, advice and assistance they have provided.

PREFACE

The following essay sketches in the history of the Indian atomic energy program. It deals in some detail with the early efforts of Canada and the United States to help the Indian program get underway, and therefore with some of the early hopes for the future of the peaceful uses of atomic energy, in particular for the production of electric power, and for the eventual discovery of a breeder that would create as much fuel as it consumes.

In discussing these early hopes, the essay mentions some of the more cautious estimates about the economic utility of this advanced technology for developing countries, and the early advice of some British, French, and American economists that these countries should wait until the technologies for nuclear electric power have been tested in practice before investing capital in them. In India, however, her desire to be the leader of the Third World, combined with the desire of Canada, the United Kingdom and the United States to bring the wonders of the atomic age to those less fortunate, have resulted in a large nuclear research establishment in India, and an ambitious program for providing nuclear electric power with all of the support facilities and skilled labor that requires.

Unfortunately, in the course of helping to build the nuclear establishment in India, and in negotiating the agreements for cooperation with India and the International Atomic Energy Agency, the United States and Canada were both lax in spelling out exactly what a "peaceful use" constraint involves. India was the country of Nehru, firmly attached to peace, if not to non-violence, and it seemed unnecessary at the time to injure the sensitivities of a newly sovereign nation by insisting on safeguards that, India claimed, violated her sovereignty. At the same time, the early fears of American scientists about the bomb potential of power reactor plutonium seem to have vanished, after efforts at the international control of atomic energy had failed. Today the United States makes clear that power reactor plutonium can be used to make a nuclear explosive that will reliably yield a kiloton or so, and that a facility to separate plutonium can carry a nation a long way down the path to making a nuclear bomb.

The Indian case illustrates the fact that present intentions never to undertake a military nuclear program are no guarantee that the government will not change its course in the future. Three events occurred in India in the sixties to open the way to a military nuclear option: India's defeat in the Sino-Indian border war in 1962, the Chinese nuclear weapons production program, issuing in a series of tests beginning in October, 1964, and India's brief war with Pakistan in the Fall of 1965, during which the United States cut off aid to both India and Pakistan.

When India exploded a nuclear device on May 18, 1974, the United States took the position that India had not violated the specific contract with the United States on the Tarapur reactor, because the plutonium used in the explosion had been extracted from the spent fuel in the Canadian-supplied reactor, the CIRUS. Some members of the U.S. Congress were not satisfied with this explanation, which overlooked the peaceful use constraint on Indian use of American supplied heavy water in the CIRUS, and which seemed to disregard India's violation of the spirit of the agreement on nuclear cooperation.

The Canadians on the other hand stopped work under their agreement for the Rajasthan power reactor complex immediately after the explosion, even though it was plain that RAPP II, the second Rajasthan reactor, had nothing directly to do with the explosion. In May 1976 they refused finally to renew cooperation with India, since India refused to abandon its nuclear explosive program and would only defer it until completion of RAPP II. Since then Canada has refused cooperation with such countries as Pakistan, which have refused to disavow nuclear explosives.

The author believes that Canada's choice of policy is the one that the United States should follow: further nuclear cooperation with non-weapon states should be premised not merely on their literal fulfillment of all agreements with the U.S. government, but on their entire nuclear program, and on the question as to whether that program is serving exclusively peaceful aims or advancing military ones also. Today in India the new administration is headed by Morarji Desai, who has been on record since the sixties against nuclear weapons for India, and who has already -- in the first days of his governance -- called into question the usefulness of a nuclear explosive program for India. It would seem appropriate for the United States to take advantage now of this significant change from the policy of Indira Gandhi. Specific policy suggestions are spelled out at the end of this essay.

1. "THE BUDDHA SMILES": ABSENT-MINDED PEACEFUL AID AND THE INDIAN BOMB

SUMMARY OF SOME MAJOR POINTS ON INDIAN NUCLEAR EXPLOSIVES*

1. Plutonium and the early Indian nuclear program

The Indians decided in 1958 to produce and separate plutonium, long before they decided to make a nuclear explosive. So did the British, and so did the French. The Indians had separated plutonium in their Phoenix reprocessing plant by 1965, years before they had any power reactors in operation, and the decision to separate plutonium had no persuasive economic justification. It was tied to plans in the 1950s for developing an Indian breeder reactor which is still remote in the 1970s. However, India's plans to produce plutonium with only a tenuous and vague relation to a realistic program of power production were not very different from the vague expectations of the U.S. and the U.K. in the 1940s and the 1950s about the utility and even the necessity of plutonium in the production of electric power.

Whether or not Indian plutonium ever became important in the generation of electricity, the separated plutonium would carry India most of the way toward a nuclear explosive. The same would be true for any country acquiring substantial amounts of separated plutonium. Neither our export policy nor that of any other country had recognized this fact nor seriously tried to cope with its consequences until President Ford's announcement of October 28, 1976.

2. First steps to a bomb

It appears on the basis of public evidence that sometime in late 1964 Prime Minister Shastri had given Homi Bhabha, the director of the Indian AEC permission to reduce the critical time needed to make a nuclear explosive. Bhabha had stated some time before his death early in 1966 that India could make a bomb in 18 months, and by the spring of 1966 some Indians were claiming

*These points are not an outline following the order of the monograph; instead, they pick out some of the main conclusions that emerge from an analysis of the Indian case.

it could be done in 6 months.* Evidently Shastri's permission set in motion work on design of an explosive system and preparation for testing of the non-nuclear components. This preliminary activity would still leave open the question as to whether India would assemble a nuclear explosive, and also the question of whether with the explosive at hand, India would choose to detonate it. Shastri's private relaxation of his public stance was motivated primarily by concern about China, and the decision to go ahead with military components was given greater impetus by the withdrawal of American military aid in the fall of 1965.**

3. Minor events can tip the decision in exact timing of a test

India illustrates that, with cumulating changes that shrink the critical time, only a minor event is needed to tip the decision in the timing for exploding a nuclear device: for example, a mere "tilt" toward Pakistan by the United States rather than a reversal of alliance, or a need for a distraction from transient domestic economic troubles, such as a railroad strike. The basic decision to come close to making a bomb has to do with more fundamental, long term interests.

4. Shrinking critical time rather than merely preserving the option

One frequently talks of a given government trying to preserve the option to become a military nuclear power. But the phrase is misleading. A sovereign government cannot surrender such an option in perpetuity, even if it renounces the possibility with fewer qualifications than in the Non-Proliferation Treaty (NPT). It can always change its mind and, starting from where it stands in nuclear technology, proceed to get weapons.

* See pp.3-95, 96, and 3-101 ff. of this Monograph.
**See pp. 3-101 ff.

The Indian case, however, illustrates the more important phenomenon, namely that a government can, without overtly proclaiming that it is going to make bombs (and while it says and possibly even means the opposite), undertake a succession of programs that progressively reduce the amount of time needed to make nuclear explosives, when and if it decides on that course. This can be done consciously or unconsciously, with a fixed purpose of actually exploding a device, or deferring that decision until later. But it is more than holding out the option. It involves steady progress towards a nuclear explosive.

5. The linkage of decisions to explode a nuclear device

The Indian program illustrates the linkage of decisions among antagonists to get nuclear explosives, and also the fact that the linkage is not a mechanical phenomenon, but related to a network of competing national interests and domestic factions. The Chinese nuclear explosion in October, 1964 followed the Sino-Indian conflict in 1962 which itself had been a flaring into the open of the rivalry between the two Asian powers, previously smothered in the rhetoric of co-existence. The Chinese explosion generated a policy debate among Indian domestic factions that led more or less steadily to a nuclear explosion nearly ten years later. The beginnings of the nuclear explosive program were clearly visible for at least 8 years. The Indian explosion in turn, following Pakistan's disasters in the 1971 war, may confirm Pakistan's decision to get nuclear explosives, "even if," as Prime Minister Bhutto said, "we have to eat grass." The consequences of both the Chinese and Indian explosions involved not only such direct links, but a more generalized lowering of the taboo.

6. The rhetoric of peace and economic development

The rhetorical separation, as if in a dichotomy, of peaceful and military uses of nuclear energy, and the rhetorical identification of investments in civilian nuclear energy with economic development and catching up with the advanced countries, form a substantial part of the background of cumulative changes that made the nuclear explosive program easier.

The identification of civilian nuclear energy with economic progress is sometimes made in self-consciously symbolic terms with no pretense at hard economic argument, but merely as an invocation to modernity. Nuclear technology, it is said, is the most important or most characteristic art of the present age -- "the nuclear age." Therefore it becomes the essential for catching up with the advanced countries, from which India and other less developed countries have only recently been liberated. Dr. Bhabha, the first director of India's nuclear energy program, argued steadily in this vein against the economic arguments of Francis Perrin, I.M.D. Little and others. He was aided by the rhetoric of Atoms for Peace, and his early implementation of the Indian civilian nuclear program found strong support in AID and the AEC of the 1950s as part of a general and generous U.S. policy to aid third world development.

7. The rhetoric of disarmament

The Indians also use the rhetoric of nuclear disarmament and "general and comprehensive" disarmament as ultimately justifying their production of nuclear bombs: (a) nuclear armament would put them in a powerful position to argue for nuclear disarmament (a standard argument by intending nuclear powers), and (b) the only alternative to India's nuclear armament is unattainable, namely the disarmament of the superpowers and of their own major antagonist China. Indian rhetoric here exploits the insincerities and the hopes expressed in the rhetoric of the weapons powers themselves. Off the record interviews at crucial periods make plain however, that Indian officials would put no trust even in an agreement by China to disarm totally. No such promise to disarm will substitute for an Indian nuclear weapons program since, they say, there is no way of verifying the non-existence of Chinese bombs in the vastness of China's territory.*

This is the reality underlying India's part of the debate on Article VI of the Non-Proliferation Treaty.

8. The danger of relying on evasive assurances.

In spite of the long gestation period, when the Indians were plainly moving toward a nuclear explosive, U.S. experts both inside and outside the government have tended to take Indian arms control rhetoric at face value. One excellent student of proliferation (Harold Feiveson) reported in 1973, shortly before the explosion, on a consensus of U.S. experts that the Indians would not explode a nuclear device.

9. The importance of national sovereignty in the less developed countries

Frequently in arms control negotiations we think of countries like India as hostile to any surrender of sovereignty in an alliance, but as quite willing to accept limitations by a truly universal international authority. The Indians, as they prepared their nuclear program, were sedulous attendees at Pugwash conferences, as well as highly vocal parti-

*See supra, p. 3-95, 96.

cipants in the Eighteen Nation Disarmament Committee. However, it is apparent that India, like many other less developed countries, has been among the most jealous of surrendering any part of its sovereignty to an international inspectorate. It has fought against harassment by IAEA inspectors and used some of the indirectness of the trilateral relationship to keep as much freedom of action as possible, and specifically freedom from restrictions imposed by suppliers. Its agreement on nuclear cooperation with the United States and the IAEA is unique in that safeguards apply only to the enriched uranium fuel supplied by the U.S. and not to equipment.

10. <u>Ambiguities that weaken sanctions</u>

The ambiguities of agreements on the Indian nuclear program are central to the problem. Did the Indians violate any agreement in literal terms? Even if they have not violated the exact terms of an agreement, or even if they can argue that they did not, did their actions represent a dangerous shrinking of critical time?

The United States government has made clear since 1966 that there is no distinction between a peaceful and a military explosive. But the Indians act as if the non-exclusive "and/or" were in fact a dichotomous "either military or peaceful, but not both." This poses problems for sanctions.

11. <u>Sanctions and the costs to those who impose them</u>

Precisely because Indian behavior did not overtly and plainly violate the letter of agreements as the Indians chose to construe them, the decision to impose sanctions was vulnerable to arguments that the sanctions imposed costs not only on the Indians but on the United States.

U.S. suppliers were heavily involved, following the spirit of the original open-handed Atoms for Peace program and later of Article IV of the Non-proliferation Treaty that promised "the fullest possible exchange" to help civilian nuclear energy programs.* (While Article IV was directed especially at parties to the Non-Proliferation Treaty, it also stipulated "due consideration for the needs of the developing areas of the world". And though the rights and duties under Article IV are limited by the obligation in Article I, "not in any way to assist non-nuclear weapons states to manufacture or otherwise acquire...nuclear explosive devices", many non-nuclear weapon states in this context conveniently forget Article I and the fact that this is a non-proliferation treaty, not a nuclear development treaty.) The machinery of grant aid and concessionary loans was nowhere more utilised than in the Indian case. In our agreement with India we also undertook various obligations (to send enriched uranium for reloads frequently enough to keep the reactors operating, and to provide continuing technical assistance). These are contingent of course, upon India's fulfilling her obligations. However, if she does not, and if we stop our assistance, we do so at some domestic cost to American business. At the very least American business will be smaller than if we take a relaxed view of the customer's obligation to eschew nuclear activities with a potential for military application.

Besides American business, there might also be objections from members of the relevant Congressional committees and the media, who would feel after the so-called Pakistani tilt, that the U.S. government was picking on India. Other factors also reinforce the reluctance to impose sanctions: some members of the U.S. bureaucracy think the Indians were right; some were involved in negotiating the original agreements with all their ambiguities; some, as always, find it pleasanter to distribute rewards rather than punishments and dislike being cast in the role of heavy, perhaps especially with respect to a less developed country that seems intermittently to be on the brink of famine, and find the specter of responsibility for bringing on one such famine hard to live with. For example, a breakdown in electric power might decrease fertilizer production which in turn might affect the crops in Gujarat, and so on.

Although the U.S. had and continues to have considerable leverage in the continuing Indian need for help from General Electric when they run into trouble with operating the boiling water reactors at Tarapur, and in the Indian need for slightly enriched uranium, heavy water, etc., it is easy to understand why we have been reluctant to use the leverage.

12. Ambivalence

There is in any case an ambivalence in U.S. policy. We have been against proliferation in general, but not necessarily in particular. Non-proliferation is only one of a number of foreign policy goals, and those who stress it excessively tend to be regarded as fanatics, "one-issue men." If in fact the occasions for application of sanctions are blurred by ambiguity, and the effectiveness of the sanctions themselves seems weakened because we no longer hold a monopoly on the services we might threaten to withhold, and since our influence over other suppliers is limited, policy is likely to be affected by a feeling of the inevitability of the spread. From there it is a short step to reviving the comforting doctrines, popular especially in the late fifties, that the spread would not be so bad anyway. If we don't actually enjoy it, we might at least relax.

13. <u>Ambivalence is likely to reinforce the ambiguities</u>

Our own ambivalence and that of other supplier countries and the implicit rivalries among them make for a failure to press for very clear bilateral understanding as to what is proscribed. (Canadian and U.S. temporizing in the mid-1960s illustrates this.) Unilateral understandings, no matter how explicitly transmitted, are no substitute. (Trudeau's plain talk to Indira Gandhi shows this. She was not talking -- and not listening either.) Canada's recent decision to stop aid on the RAPP II reactor has finally drawn a clear line between safe and dangerous activities. Her actions clearly say that a nuclear explosive is not exclusively peaceful.

14. <u>Intelligence, ambiguity and ambivalence</u>

The U.S. intelligence function is weakened by the fact that it is not very clear what it should look for (a violation? A legitimate activity that is "unsafe?") and whether there is much point in looking for it, since there may be no clear policy to do something with the information and no urgent need expressed in advance. May 18, 1974 marks a failure to clarify our policy on response more than a failure of intelligence.

15. Primitive versus sophisticated capabilities

The Indian program proceeded slowly over a very extended period under a nominal cover, but with many obvious indications that they intended at least to explode a device and get a few primitive weapons. Partly because of this manner of proceeding, the Indians are a long way from having a serious nuclear capability against their major adversary, China. They suffer moreover from many geographical strategic asymmetries for this purpose. It is conceivable that they may proceed with a missile program at the same stately pace. On the other hand, they do have sizeable ambitions in the world strategic environment, (the title of their Defense Journal is India in the World Strategic Environment). Though extremely poor on a per capita basis, the country is large enough to have a GNP that can support a substantial military program, and possibly in the future a much more extensive military program than a simple last resort capability usable only in response to an overwhelming conventional attack and with little hope of surviving nuclear attack. It might even go for a blue water navy.

16. Nuclear versus conventional

The Indian conventional forces have been considerably strengthened. The military in the mid-sixties plainly regarded nuclear weapons as a rival to such conventional expansion and therefore did not support it. But as such conflicts frequently are resolved, the military got their conventional expansion and the Foreign Office and the Atomic Energy

Department got their nuclear explosives, with consequent increasing military support for the nuclear program. An expanded military nuclear program might in the future get wide general support.

17. Non alignment and guarantees joint and individual

The Indians continued to maintain a non-aligned stance in the mid-sixties long after the conflict with China and regional antagonisms had transformed the meaning of non-alignment. Nonetheless it made them reluctant to try to get an unequivocal unilateral guarantee from the U.S., which might appear to line them up with the U.S. They actively sought a joint guarantee from the Soviet Union and the United States, even though some high officials recognized that such guarantees among potential adversaries are worth considerably less than alliance guarantees. In the end the Non-Proliferation Treaty was followed by an extremely weak statement of guarantee by the weapon states that they would take "appropriate action" according to the decision of the Security Council. When this was passed in the Security Council, India as well as France abstained, though it was the end point of a sequence of actions seeking a guarantee in which India had played a leading role.

THE BACKGROUND*

The Indian nuclear program has a long history, and its direction was partly determined by the British training of India's scientists. Two scientists in particular stand out in this history: Meghnad Saha and Homi Bhabha. Saha, the elder of the two was born of a poor family in East Bengal, and went through many trials and difficulties to receive his education in India. It was only later as an established physicist that he was able to visit the laboratories and universities of England and Germany. Bhabha, on the other hand, came from an aristocratic family in Bombay, and enjoyed all the advantages of music, art and a fine library in his home, and went to Cambridge University in England for his education. Yet in spite of these differences and some professional rivalry, the two shared the same dedication to the advancement of science in their country, and to the solution of its pressing economic problems.**

India achieved her independence on August 15, 1947. During the last few years of struggle, Saha had given much thought to India's economic problems. Writing in February 1945 he deplored the fact that "Indian leaders have so far paid attention only to the question of political

---

* I am indebted to Jacob Scherr for making available his collection of State Department and ERDA materials, obtained through the Freedom of Information Act. (hereafter referred to as ERDA op. file)

** The best account of this early development can be found in Robert S. Anderson, Building Scientific Institutions in India: Saha and Bhabha, Occasional Paper Number 11, (Montreal: Centre for Developing-Area Studies, McGill University, 1975) freedom. . . but the problem of living for millions of Indians cannot be postponed."* Saha focused on electrical energy as the major means for advancing the standard of living. His goal was to see that "India's <u>per capita</u> income should be progressively increased to modern figures compatible with her resources; and as a necessary first step, India's energy-index should be progressively increased to the figures attained in all modern countries."** He set a goal of 100 units per head within the next ten years, as against the current production of nine units, pointing out that this was only slightly larger than the production of energy in the United Kingdom just prior to World War II. Saha was thinking of India's resources in coal and water to produce electrical energy. But the ideal of wide-ranging and large-scale electrification of India became for many scientists and government advisors the panacea for India's economic ills. For Bhabha this vision of the future assumed a nuclear form after news of the Manhattan Project had reached him. It appeared that nuclear energy could be harnessed in civilian power reactors and that India's salvation ~~was~~ might be close at hand.

It is worth pausing here to make some observations about this strong focus on electrical energy as the lever for lifting India into the modern world, or at least for raising its per capita income to the level in the advanced states. That focus presumes a causal relationship between energy and income which has played a role not only in India's nuclear planning, but in the market studies that continue to be made by the IAEA

* Meghnad Saha, "Science in Social and International Planning, with Special Reference to India," <u>Nature</u>, Volume 155, Number 3930, (February 24, 1945), p. 224.

** <u>Ibid</u>., p. 222.

for other developing countries.* The causal assumption proceeds from the fact that per capita GNP in various countries is highly correlated with the per capita use of electricity. Saha, writing in 1945, cites statistics to show this, and in general it is true that the rich use more electricity. But what does this signify? The rich use more motor cars, more food, more yachts, more leisure and many other goods and services. Yet we would not ordinarily assume that they are rich because they use more of these things, but rather the other way around: They use more of these things because they are rich. In fact, statisticians and econometricians make no end of warning us about such pseudo correlations and have devised several methods of varying degrees of sophistication to sort out the significant from the apparent relations.** Indeed, several excellent economists have made the point in connection with the Indian program. Nonetheless this focus on energy as the key strategic variable in economic development seems to come rather naturally to physicists. Energy is, of course, a most fundamental quantity in physics, and it is natural for physicists to think that it should play the same

Mason Insert

---

* See, for example, IAEA, Nuclear Power Planning Study for Pakistan (Vienna: IAEA, 1975).

**One standard method is to see whether differences in income are positively related to differences in the price of energy. Both Edward S. Mason and Philip Sporn in the 1950s showed that there was little or no dependence of differences in per capita income on differences in the price of energy, that for example, some of the poorest countries that used energy least also had it available at extremely low prices, as in the Middle Eastern oil countries. The same observation could be made about differences within the United States and about historical time series.

role in economics. Just as economists in the seventeenth and eighteenth centuries generated theories of value in which land was the fundamental unit of value and later developed a labor theory of value, physicists and engineers have a leaning toward BTU or Erg theories of value. In fact the technocrats of the 1930s were quite explicit about the importance of substituting ergs for dollars as the unit of account. And currently there has been a kind of revival of this technocratic view in the form of "Net Energy Assessment" which in effect treats energy as the only scarce resource.*

Bhabha had himself absorbed the idea of bringing electricity to India's villages from his British mentor, Sir John Cockcroft, and especially from the Nobel physicist, P.M.S. Blackett, a close friend, who professed to be a marxist. Blackett in turn seems to have derived it from Saha,**so Bhabha may have received it in Bombay out of Calcutta by way of London. In any case, his connection with the British physicists was very close and they had a very sympathetic view of the importance of improving the position of science in India as well as of advancing the economic development of India herself.

During the second World War, Bhabha had been impressed, while in charge of a special cosmic ray research unit at the Indian Institute of

---

insert title - E-1

* On these points, see ~~Monograph I~~ of this report and also H. G. Simmons, "Systems Dynamics and Technocracy" in H.S.D. Cole, C. Freeman, M. Jahoda, K.L.R. Pavitt, editors: Thinking About the Future, Chatto and Windus for Sussex University Press, London, 1974, and Henry Elsner, The Technocrats, Syracuse University Press, Syracuse, 1967.

**Political and Military Consequences of Atomic Energy (London: Turnstile Press, 1948), p.90. Blackett cites Saha while commenting on the "well-known correlation between per capita income and per capita energy consumption". The supposedly crucial role of electricity is also found in the old Lenist slogan (1920) "Communism is theSoviets plus electricity."

Science at Bangalore, with the poor funding and consequent shortcomings of Indian science. The equipment and facilities were inadequate and could not attract scientists; the administrative and teaching burdens left little time for research; and the salaries were such as to turn most able university men towards commercial or administrative careers. He therefore suggested to the Indian philanthropist, J.D.R. Tata, that an institute for fundamental research in physics be founded with the funds of the Sir Dorab Tata Trust. The Tata Institute of Fundamental Research, often referred to simply as the Tata Institute, was founded in June, 1945 at Bangalore. It later moved to Bombay and in 1949 moved again to a beautiful and spacious site near the Bombay Harbour. Bhabha became the first director, and from the beginning he had in mind the development of abundant and economic nuclear power. In a sentence frequently quoted from his letter to J.D.R. Tata of March, 1944, he foresaw "nuclear energy...successfully applied for power production, in say, a couple of decades from now...."* As his successor at the Tata Institute wrote in a memorial piece after Bhabha's death, "I would like you to remember that this was written by one sitting in Bangalore in 1944; this letter was written more than a year before Hiroshima; the work on the atom bomb was being carried out with the greatest secrecy in the West; the only knowledge Homi Bhabha had was that nuclear fission had been discovered."** Bhabha's prediction in 1944 seemed almost magical to

---

* M.G.K. Menon, "Homi Jehangir Bhabha," *Proceedings of the Royal Institution of Great Britain*, Volume 41, Part IV. Number 191 (1967), quoting a letter of March 21, 1944 from Dr. Bhabha to the Sir Dorbji Tata Trust, p. 426.

***Ibid*.

later commentators, and the building of science, especially in the nuclear field, and its application to electrical energy, became the magic formula for changing this poor country into a rich one, enabling it to move in one leap abreast of the major industrial powers. ("Magic" may not be the right word. In October of 1944, Saha and several other Indian scientists had toured British, American and Canadian laboratories. In the United States, they visited Caltech, Harvard, Chicago, Princeton, the Carnegie Institution, Pittsburgh, MIT, and the TVA. It was only late in the trip that an American scientist warned them that "enquiries about 'nuclear power' were forbidden."* While Bhabha did not go on this trip, it seems likely that he heard the results. The tour illustrates India's early nuclear interest as well as the favored position of Indian science in the U.S. and the U.K.)

Saha probably formed his vision of the Indian future in a period when he was unaware of the possibility of substituting nuclear for fossil fuels. Bhahba saw that future very early as a nuclear one. His views, expressed so clearly at the moment when the movement for Indian independence was about to achieve its goal, form an obvious contrast with Mahatma Gandhi's vision of independence and the future of India. For Gandhi, it is familiar, the apparent backwardness of India was a virtue and a token of India's superiority to Western civilisation. "It was not that we did not know how to invent machinery, but our forefathers knew that, if we set our hearts after such things, we would become slaves and lose our moral fibre. They therefore, after due deliberation, decided that we should do only what we could do with our hands and feet."** The spinningwheel and the small village using cow dung as fuel

*Anderson, op.cit., p.45.

**Quoted p.58 of Elie Kedourie, Nationalism in Asia and Africa, The New American Library, Inc., New York, 1970.

symbolized the kind of self-sufficiency that Mahatma Gandhi had in mind. Even to study European medicine, he felt, was "to deepen our slavery."*

Nothing would seem to contrast more starkly with Gandhi's pastoral idyll than Bhabha's cosmopolitan view of the need to seize the most advanced Western science to propel India into the modern world, to launch it in one explosive effort from the village use of cow dung to the large scale exploitation of nuclear electric power and to attain self-sufficiency ultimately through the use of Indian monazite sands and the development of thorium breeder reactors. Nonetheless, for all the obvious and valid contrasts, there are some points in common. Bhabha did have as his goal national self-sufficiency and it would be a mistake to take at face value the notion that he was expressing, in contrast to the Mahatma, an unsentimental and soberly calculated, empirical and rational view of the future. On the contrary his view on close examination had a good deal of the romantic visionary. His was a technocratic as distinct from a pastoral idyll.

Bhabha and Nehru shared the same hopes for India, and Nehru, who fancied himself a natural scientist from his Cambridge days, gave full support to Bhabha's attempts to implement them. Bhabha became chairman of India's Atomic Energy Commission, founded in 1948 by the Atomic Energy Act. Under his dynamic leadership, a Department of Atomic Energy was created in 1954 as part of the Ministry of Natural Resources and Scientific Research. By 1955, 200 scientists were at work and Trombay had been selected as the site for assembly of India's first research reactor, APSARA, named after one of the celestial water nymphs of Indian mythology. Trombay became the site of the Atomic Energy Establishment (DAE) as well as the Bhabha Atomic Research

---

* Quoted p.58, Ibid.

Center (BARC). The cluster of buildings and fine gardens, as well as the works of art in the corridors and offices are justly famous, and attest to Bhabha's careful attention to even marginal details of his ambitious program. At his death in 1966, at the age of 55, he occupied the posts of Director and Professor of Theoretical Physics at the Tata Institute, Director of the Atomic Energy Establishment at Trombay, Secretary to the Government of India in the Department of Atomic Energy, ex-officio Chairman of the Atomic Energy Commission of India, and Chairman of the Scientific Advisory Committee to the Cabinet. He began in 1945 with a budget of Rs 80,000 for the Tata Institute; 20 years later, he was managing a budget for the DAE of Rs 115 million, of which the Institute received Rs 15 million.* The Institute's health was closely related to the growth of the DAE. Its group of scientists in electronics under A.S. Rao and in nuclear physics under R. Ramanna (now well known for his association with the first Indian nuclear explosion) later moved to Trombay. The Institute's scientists also built the control system for APSARA.

From the beginning, Prime Minister Nehru stressed self-sufficiency as one of the prime goals of India's nuclear energy program. His desire for self-sufficiency was related to his sensitivity about Indian sovereignty, a feeling which he shared with all of India's elite, for India was only recently sovereign, and was extremely ambitious to lead

---

*Anderson, op. cit., p. 82. Prior to devaluation on June 8, 1966, the rate of exchange was $1 = 5 rupees. A rough adjustment for inflation, (using the "consumer price index for urban non-manual employees") would yield Rs 135,000 in 1966 Rs for Rs 80,000 in 1945. The Government of India, Economic Survey, 1974-75, New Delhi, 1976, p. 93.

the poor countries of the world. The desire for leadership in nuclear energy was only one aspect of the more general ambition; it was reflected in the Indian rejection of an early American proposal for a regional reactor training center elsewhere in Asia,* and in its acceptance from Canada of the CIRUS reactor--to be located in Trombay. (This gift from Canada under the Colombo Plan meant accepting the use of Canadian engineers, even though Nehru and Bhabha were in principle opposed to turnkey operations. However, getting the first large-scale--40 megawatt thermal--research reactor in Asia apparently was worth accepting some dependence on Canada.) The desire to be first in Asia in nuclear energy and the need at all points to assert Indian sovereignty are illustrated in many other ways--for example, in India's extreme resistance to safeguards on special nuclear material, in the desire to build all parts of the nuclear fuel cycle and to make all nuclear facilities truly Indian, both in personnel and materials. Hence the early interest in thorium breeders, since India was especially rich in monazite sands, from which thorium--a fertile nuclear material--can be extracted. Fuel fabrication facilities were among India's first atomic installations, and by August 1962 India was manufacturing fuel rods for the CIRUS reactor, and in early 1963 began production of heavy water at its combined heavy water and fertilizer plant in Nangal. As early as 1958 a chemical reprocessing plant was decided upon and after several years of work on design, construction began in April 1961.

---

*New Delhi Embassy notes of March 27, 1956, p. 3, commenting on Embassy New Delhi Dispatch 697, December 29, 1955. ERDA files. Manila was the site tentatively selected. Nehru characterized the U.S. proposal as "paternalistic."

This reprocessing plant was to separate plutonium from the spent uranium fuel of the CIRUS. As Nehru explained to the Lok Sabha (the Parliament), "Plutonium is of great importance, as it is not available as a commercial commodity. Its production is essential in order to enable the country to set up breeder power stations using thorium which we have in ample measure."*

It is interesting and characteristic of Nehru that he should have talked to the Parliament of a decision to separate plutonium for use in a breeder without any indication of when breeders would be available to consume the plutonium for the initial loads. The breeder was of course many decades away, but at this time the Government of India had not yet even contracted for a converter power reactor--one that produces fewer fissile atoms than it burns in generating electricity--where it might have been possible to recycle some of the plutonium. But apparently no one at this time in the Lok Sabha, the Canadian Atomic Energy Commission, or the U.S. AEC raised any questions about the timing of a breeder for India, or in particular about the costs and likely uses of a plutonium separation plant with a capacity of 100 MTU of spent fuel per year, scheduled to operate long before plutonium could be used as a reactor fuel.

The concept of the breeder which generates more fuel than it consumes while making electric power, and is in this sense self-sustaining, seems to combine the two ideals of independence and wealth through electric power. Bhabha had been fascinated by this idea from the first, and argued persuasively for it in 1955 at the first Atoms for Peace conference. He did not think of the breeder as an option, but as a

---

*Speech of August 10, 1960, quoted in R. Rama Rao, "India's Nuclear Progress--A Balance Sheet," India Quarterly (October-December, 1964) categorical imperative.

> . . . it is absolutely necessary to build atomic power plants . . . which will breed new fissile materials at least equal in quantity to the amount burnt. In terms of our present technical knowledge this requires the availability of enriched or pure nuclear fuel, which has either to be extracted from natural uranium in a gaseous diffusion plant, or generated from natural uranium or thorium in power reactors designed to operate on natural uranium and to produce this conversion. Since it is the intention in India to avoid the construction of a gaseous diffusion plant, it is clearly necessary to set up in the initial stages atomic power stations which operate on natural uranium and effect the maximum conversion of fertile to fissile material. This pure or enriched material could subsequently be used in breeder power stations, thus enabling our entire reserves of uranium and thorium to be utilised for power production. On this basis the reserves of uranium and thorium indicated are equivalent to 600 thousand million tons of coal, which is more than 15 times the known reserves of coal. Atomic energy therefore substantially relieves the situation mentioned.*

Bhabha's interest in reprocessing and in the breeder was noted by our New Delhi Embassy in 1956, but seems to have aroused no further American comment at the time.** Surprisingly in these American 1956 reports no trace remains of the concern about nuclear explosive material that had preoccupied government officials and scientists in 1946 and 1947. The political and military implications of stockpiling plutonium were to be a subject for the seventies, not for the fifties, nor even very much for the sixties.

---

* "The Role of Atomic Power in India and Its Immediate Possibilities," Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, Volume I (August 1955). (New York: United Nations, 1956), p. 107

**New Delhi Embassy Note, March 27, 1956. Comment on New Delhi dispatch 901, February 17, 1956, p. 1. "Very interested in 'breeding' and 'our next attempt should be to develop a material in which thorium is used as a source for breeding and power generation.'" ERDA open files.

In pursuit of nuclear independence and leadership, Nehru also sought to diversify his sources of supply. He negotiated with the U.K., France, Belgium, Canada and the United States for equipment and material, and made every effort to develop and control local Indian resources. The Atomic Energy Act had given the Government of India general control over nuclear materials. As early as 1952 Nehru extended that control to prevent export of any material connected with the manufacture of an atomic explosive,* and in 1953 required a government license for anyone to acquire or deal in such materials as radium, zirconium, deuterium, pitchblende, columbite, smaarskite, uraniferous allanite, monazite, ilmenite, zircon, rutile, beryl, and uranium-bearing tailings left after copper or gold mining. His motive here was to have in hand the raw materials with which to bargain for nuclear assistance. The U.S. in particular was concerned over the need for thorium.**

Both Bhabha and Nehru also put great emphasis on the training of Indian nuclear scientists and engineers. The Tata Institute itself had been designed partly to insure a supply of local scientists so that India, as Bhabha put it, would not have to "look abroad for its experts," but would find them "ready at hand."*** For Bhabha believed that "trained scientific and technical personnel are the most precious asset in any atomic energy program."**** Trained scientific and technical personnel

---

* Michel A.G. Michaud, "India as a Nuclear Power," paper for National Security Studies Program, University of California at Los Angeles, June 1963,pp. 23 ff. This paper clearly reflects India's early ambitions and hopes for nuclear energy, and its ability to put her in the ranks of the great powers.

** Memo prepared in the Office of the Under Secretary of State (Lovett), "Outline of Indian Atomic Energy Situation, Sept. 17, 1948" Foreign Relations of the United States, General; The United Nations 1948, Vol. 1, Part 2, USGPO 1976, pp. 758-780.

*** Letter to J.D.R. Tata, op. cit.

****IAEA/CS/OR/28 Conference on the Statute of the International Atomic Energy Agency. U.N. Headquarters, October 15, 1956, verbatim.

are of course a precious asset not only in an atomic energy program, but also in a program of economic development to increase per capita gross national product in a poor country. And so are skilled labor and managerial and entrepreneurial personnel. But there is a serious problem here hidden in talk of science and technology in general, and in a particular focus on the production of nuclear energy rather than the improvement of technology on a broader front.

The atomic energy program involved the training of physicists and nuclear engineers in a very high technology that was quite specialized in its immediate application. Because of the spectacular achievement of this specialized knowledge in the development of military nuclear explosives, it was all too easy to treat the program symbolically, as a matter of acquiring a badge or medal of technical advance. It was also easy to assume that the application of nuclear energy in the generation of electrical power would have equally decisive and impressive results, and those very quickly, and to believe that this particular high technology was the best way to increase GNP rapidly and catch up with the advanced industrial countries. Bhabha in fact took nuclear energy as a method of leaping over centuries of backwardness in a grand illustration of what the Marxists call "combined development." Unfortunately, it was not all that easy ~~clear~~; indeed it was implausible that this particular technology could be the ideal vehicle for such an ambitious trajectory or even for less ambitious and more realizable goals.

First of all, energy itself while of substantial importance, is not a magic key to quick economic development. Second, nuclear electric power was not likely to offer early dramatic improvements in the competitive production of energy, especially in a poor capital-short country. Third, a good many other technologies were more accessible and in fact were pursued successfully by other poor countries then and in the ensuing years, for example, advances in technologies directly applicable to agriculture, textile manufacture, or electronics. The latter, for example, is a high technology in which a number of poor countries have distinguished themselves. In short, this symbolic emphasis on nuclear energy involved a very questionable allocation of effort in the development of scarce human capital.

The fact that overemphasis on training in nuclear technology tended to starve scientific and technical efforts elsewhere in India is witnessed by Sir John Cockcroft, Homi Bhabha's friend and mentor and one of the chief sponsors of nuclear energy development in India. In his tribute to Bhabha on the occasion of Bhabha's death in an air accident in 1966, he remarked that "the great concentration of scientific and technical effort in the laboratories of Atomic Energy, the C.S.I.R. /Council of Scientific and Industrial Research/ and Defence Sciences took place at a time when there was a serious deterioration of science in the Indian universities, some of which are lamentably lacking in resources compared with the Tata Institute in Trombay."*

---

* "Homi Jehangir Bhabha, 1909-1966," Proceedings of the Royal Institution of Great Britain, Volume 41, Part IV. Number 191, 1967, p. 421.

Whatever the effectiveness of training in nuclear energy for the overall economic development of India, there is no doubt that it resulted in a distinct improvement in the Indian capability to undertake successfully the original application of nuclear energy, namely that of designing and assembling nuclear explosives.

The United States enthusiastically endorsed the Indian nuclear program and the goal of nuclear independence for India: In particular, on Bhabha's policy of training indigenous scientists, AEC facilities welcomed Indian scientists beginning in 1955. According to the record, 1104 Indian scientists had participated in AEC atomic research by 1974, by far the largest number from a less developed country.* The number for India was in fact the highest of 84 countries, other than the United Kingdom, which it almost tied. (See Table I) The Atoms in Action program provided training in the use of research reactors, in nuclear medicine and in "industrial applications of nuclear science" by USAEC visits to non-Soviet bloc countries--35 in all between 1959 and 1969.** The Argonne National Laboratory opened its doors to scientists from these same countries in 1955. Its catalogue of courses explained that it would "present the available science and technology involved in (1) the production of reactor materials, (2) the design, construction, and operation of research or materials testing reactors,

---

* Dixy Lee Ray, "Multinational Nuclear Power--Peaceful Uses or International Terror?" Pan Am Clipper Magazine, (October 1974), reprinted in Hearing before the Joint Committee on Atomic Energy on S. 1439, Export Reorganization Act of 1976, U.S. Congress, June 22, 1976 (Washington, D.C.: U.S. Government Printing Office, 1976), p. 463.

**Ibid.

TABLE 1

Participation of non-Soviet bloc aliens in AEC research during period 1955 to date

Afghanistan	3	Jordan	7
Argentina	192	Kenya	2
Australia	164	Korea	195
Austria	179	Kuwait	2
Belgium	176	Lebanon	31
Bolivia	14	Libya	3
Brazil	133	Liechtenstein	2
Burma	14	Luxembourg	6
Cameroon	1	Malaysia	16
Canada	539	Mexico	104
Ceylon	12	Monaco	2
Chile	70	Morocco	2
China	713	Netherlands	216
Colombia	86	Norway	101
Congo	8	Pakistan	120
Costa Rica	11	Panama	14
Cuba	28	Paraguay	11
Cyprus	10	Peru	41
Denmark	96	Philippines	118
Dominican Republic	33	Portugal	26
Ecuador	13	Saudi Arabia	3
El Salvador	12	Senegal	1
Ethiopia	7	Sierra Leone	1
Finland	41	Singapore	3
France	471	South Africa	88
Germany	833	Spain	139
Ghana	10	Sweden	180
Greece	159	Switzerland	229
Guatemala	16	Tanzania	3
Guyana	5	Thailand	70
Haiti	11	Trinidad	6
Honduras	1	Tunisia	3
Hong Kong	59	Turkey	108
Iceland	9	Uganda	1
India	1,104	United Kingdom	1,186
Indonesia	34	Uruguay	22
Iran	73	Venezuela	59
Iraq	24	Vietnam	23
Ireland	32	Yugoslavia	106
Israel	250	Zambia	3
Italy	608	United Arab Republic	103
Jamaica	15		
Japan	803	Total	10,513

* In atomic energy law, this term refers to plutonium-239, uranium-233, or uranium containing more than the natural abundance (0.7 percent) of uranium U-235, or any material artificially enriched in any of these substances.

source: Dixy Lee Ray, op. cit., p. 463.

(3) the equipment and procedures for carrying out research and development in the field of nuclear energy with the aid of research reactors, (4) the handling and processing of irradiated materials produced in research or materials testing reactors, (5) the utilization of the radioactive products of reactors, and (6) the principles of design, construction, and operation of nuclear power plants and their associated fuel fabrication and chemical processing facilities."*

Again, a certain absent-mindedness is present in this American curriculum for foreigners. Training in chemical processing of irradiated materials seems to be taken as a matter of course, and finally in the sixties it is included as a chapter in a public textbook designed for beginners, with the headings, "Separations Chemistry," "Precipitation Methods," "Ion Exchange," "Solvent Extraction," and "Nonaqueous Methods."** In that chapter and in the laboratory exercises that went with it, students were taught not only the elements of how to separate plutonium from spent fuel, but they were also instructed that such separation and recycling are essential for the economics of nuclear electric power. The textbook said, ". . . consider the fuel which is removed from a reactor. It still contains an appreciable amount of fissionable material. New fissionable species, such as plutonium-239, may also be present. _For economic operations of reactors, these must be recovered_."*** Such an economic judgment

---

* "Schedule and Curriculum, School of Nuclear Science and Engineering, Argonne National Laboratory, Lemont, Illinois, U.S.A., June 1, 1955." Reprinted in the _Atoms for Peace Manual_, p. 408.

** Alvin Glassner, _Introduction to Nuclear Science_ (Princeton: D. Van Nostrand Company, Inc., 1961), p. viii.

***_Ibid._, p. 144. Italics added.

is considerably less well established than the principles of chemistry that would guide the process of separation, but this is not apparent from the simple declarative statement in the text. This sort of statement makes it easier to understand how the Indians, Canadians, and Americans who cooperated in the development of an Indian nuclear program viewed the role of chemical separation in such programs. Some questionable economics and uncritical politics were unconsciously transferred by the technicians along with instruction in engineering.

The crucial year in this history is 1955, the year when the Argonne Laboratory opened its School of Nuclear Science and Engineering. It is the year of the Bandung conference where Nehru tried to form and lead a third power bloc of the poor nations. It is the year which saw an extensive declassification of nuclear technology in the United States, in line with President Eisenhower's Atoms for Peace program. The new rules made thousands of papers and reports eligible for public circulation, including critical and detailed information on reprocessing--in particular, the PUREX method. The first United Nations Conference on the Peaceful Uses of Atomic Energy was held in Geneva in July and August of that year and there a large number of these declassified papers first saw the light. Nehru through skillful pressure and manipulation had seen to it that Bhabha as representative of a "neutral" country was made president of that conference. 1955 is also the year in which construction began on APSARA, the first Indian research reactor, and the first reactor in Asia to go critical a year later. A 1 MWt reactor of the "swimming pool" type, moderated by ordinary water and fuelled with enriched uranium, its stated purpose was to produce radioactive isotopes for medicine and industry. It was built in a year's time by Indian engineers with the encouragement of the British. Sir John Cockcroft had arranged for England to supply the fuel elements, and he also had been helpful in staffing the chemical division at Trombay in its early years.

And, finally, 1955 is the year in which nuclear cooperation under the Atoms for Peace program really got underway. By July 1955, the U.S. AEC had negotiated agreements, either initialed or signed, with 27 nations.

Early that year a Raw Materials Subcommittee of the Joint Committee on Atomic Energy visited a number of countries "to explore at first hand how bilateral agreements for cooperation, made possible under the provisions of the new Atomic Energy Act of 1954, might be achieved rapidly."* Its report illustrates the atmosphere at the time, the great hopes for what atomic power can do for underdeveloped countries, and the need for the United States to act quickly to prove its "good will" and "good intentions."**

---

* "Report of the Raw Materials Subcommittee on its Visit to Australia," February 9, 1955. Joint Committee on Atomic Energy Print, (Washington, D.C.: U.S. Government Printing Office, 1955), p. 1.

**_Ibid._, p. 3.

The Committee visited New Zealand, the Commonwealth of Australia, the State of South Australia, the Philippines, Formosa, Thailand, India, Pakistan, Iran, Turkey, Greece and Spain. It was particularly impressed with what it saw in India. After meeting with Dr. Saha and his staff at the University of Calcutta, and with members of the Indian Atomic Energy Commission in New Delhi, it concluded that "the Indian atomic effort is an important one not only to India but to the advancement of science."* It elaborated in some detail on the Indian effort, and offers an early mention of the transfer of U.S. heavy water to India, which was later to be used in producing the plutonium for the first Indian nuclear explosion.

> An outstanding example of the assistance which the United States can render at little or no cost was encountered in India. There the Government has plans for the construction of a large research reactor /the CIRUS/ which will use heavy water as a moderator. The Indian Government is already beginning construction of a heavy water production plant which it has every reason to expect will be able to furnish the quantity necessary by the time this first large research reactor is ready to start operating. *What the Indians need is an assurance from the United States that, in the unlikely event that their own heavy water production plant falls behind schedule, they can rely on a loan of heavy water from the United States to get their reactor in operation promptly.* In the first place, the Indian production schedule appeared to us to be realistic; in the second place, even if the United States should have to loan this material to India, it would certainly be for a reasonable time. The total cost of our assurance to India would be no more than the theoretical interest on *the heavy water inventory which might be tied up for a few months in their reactor.* Such an assurance from us would constitute the kind of genuine cooperation from the United States that is needed to prove our good intentions.**

---

* *Ibid.*, p. 10.

***Ibid.*, p. 3. Italics added.

The "unlikely event" occurred. The Indians, as it developed, needed to borrow heavy water not just for a "few months" and not just for CIRUS, but for all of their reactors that used heavy water as a moderator or a coolant: for Zerlina, for CIRUS, and in very large quantities for RAPP I, their first natural uranium power reactor built on the CANDU design. In fact, since their entire program has stressed natural uranium reactors as a means of avoiding dependence on imports of enriched uranium from overseas, a large supply of heavy water has been critical for them. Their own program to produce heavy water has run into many difficulties and as a result they have simply reduced their dependence on low enriched uranium by acquiring a dependency on heavy water. The remainder of their program involves very large quantities of heavy water for RAPP II and for the Madras reactors, and as of 1974, the Economic and Political Weekly of Bombay reported, "In addition to uranium resources, the availability of heavy water has become an immediate constraint on India's nuclear power programme. Our nuclear power programme for the seventies and early eighties is based on heavy water moderated and cooled natural uranium fueled reactors."* The article goes on to outline the situation quite clearly.

> When the present reactor technology was chosen in the early sixties, planning was initiated for the heavy water plants at various locations. A plant at Nangal has been operating for quite some time and produces about 11 tonnes of heavy water a year. This plant is, however, expected to close down completely by 1975. The Bhabha Atomic Research Centre

---

*"Heavy Water Constraint," The Economic and Political Weekly, Volume IX, Number 37, (September 14, 1974), p. 1555.

> has developed the technology of producing heavy water through the hydrogen sulphide-water exchange process. The Kota heavy water plant, based on the BARC technology, was started in 1969 and the original estimate of construction time was four years. However, five years later, the plant is still only half complete and the commissioning date has now been shifted to 1977. Several technical problems have cropped up in upgrading the laboratory level technology to the commercial scale, causing cost escalation and postponement of the completion date. It is even feared that the plant may never come up finally."

The Nangal plant is still in operation. But the hope that the Indians after initial help from Vitro International would get their own heavy water plant design and construct it themselves was also disappointed.

> Probably anticipating the Kota plant's failure all subsequent heavy water plants have been planned almost on a turnkey basis, with substantial foreign technical collaboration. A plant is being put up at Baroda with French collaboration, another at Tuticorin with Japanese collaboration and a third at Talcher with West German collaboration. All these plants are based on the ammonia-hydrogen exchange process and the BARC technology and R and D have been all but forgotten. The Indian participation in these plants is restricted to civil engineering, electrical works, construction of employees' colonies, etc.*

And even these turnkey jobs done by foreigners have not been going well. None of these plants is yet in operation. The Baroda plant, started in 1969 was scheduled to be ready in 1973, then in 1975, ~~now~~ then in 1977, ~~[illegible]~~ in December, 1977, it was seriously damaged by fire, and its operating date is still indefinite.

> The original cost estimates have been exceeded. The Tuticorin and Talcher plants are also behind schedule and are experiencing sharp cost overruns. The investment in these plants, it is currently estimated, will be of the order of Rs 100 crores. All of them taken together are expected to produce 280 tonnes of heavy water a year (around 1978). No other heavy water plant is planned for commissioning till 1984.**

---

* Ibid.

**Ibid.

The power plants at Rajasthan, Madras, and Natora will all need heavy water when they come into operation by the early 1980's. Moreover, each of these plants will require about 460 tons of heavy water for their initial charges and will require 36 tons annually to replenish operating losses because these plants use heavy water as a coolant as well as a moderator.

Compared to this enormous demand for heavy water, the small facility at Nangal is modest indeed. Either foreign heavy water or foreign aid in building heavy water plants is critical. The United States has provided the lion's share so far of the heavy water: 15 tons for Zerlina, 21 tons for CIRUS, 130 tons for RAPP I--more than half of what was needed for RAPP I. (Each power plant consists of two reactors, but RAPP II has been delayed by the Canadian decision to refuse further help after the Indian explosion. Each reactor requires an initial load of 230 tons.). As we shall see, the role of heavy water became crucial in the U.S. decision on an appropriate policy of response to the Indian explosion. In some respects the justification for U.S. action offered in 1976 seemed to presume that the optimistic evaluation of the Congressional team in 1955--that the Indians needed our heavy water only for a short while--was literally true. The Nangal heavy water plant in retrospect and in prospect has served to give the false impression that the Indians never really needed our help in that area.*

Besides these early hopes for Indian nuclear technology, the Subcommittee's report of 1955 also reflects the fears at this time of Soviet competition in the nuclear field, though apparently at this date no Soviet offers had been made to India. On the contrary, it mentions

*India's RAPP II is currently delayed for a lack of heavy water, since the Soviet Union is insisting on multiple-points safeguards. Nucleonics Week, March 24, 1977, p.8

"well-founded testimony on the complete unwillingness of the Soviet Union to bring any real benefits and contribute any real scientific and engineering knowledge to the end that the people of India may enjoy the benefits of atomic energy."* The hope that nuclear power might provide a useful counter to communist penetration of uncommitted nations provided an added incentive to American efforts to export nuclear research and power as an instrument in the cold war competition--either baldly as a gift to win allegiance, or--on the assumption that poverty drives nations to communism--as a means to raise the economic level.

President Eisenhower in rather visionary fashion had stressed the practicality of nuclear power in his speech of December 8, 1953, before the General Assembly of the United Nations. "Peaceful power from atomic energy is no dream of the future. That capability, already proved, is here--now--today." From this confident assertion, the representatives of less developed nations and many American officials and industrialists leaped to the conclusion that the economic benefits, to say nothing of the profits, would be immediate and large, particularly in providing cheap and plentiful electric power.

The President's speech had come, long after the first fine enthusiasm of the postwar era had faded, at a time of reappraisal and pessimism within the U.S. AEC, particularly during the years 1947-1952. Unfortunately, the speech had been prepared in the Executive Office with the aid of publicists and without the advice of the technically informed members

---

*Ibid., p. 10

and staff of the Atomic Energy Commission. It is conceivable that if the Commission had been consulted, it might have moderated the tone and the predictions. However, political rhetoric often has its own reasons, and close adherence to the literal truth need not be the prevailing motive. It must be granted also that presidential optimism has a way of overcoming grubby obstacles, inspiring effort and creating new truths.

Subsequently, some government officials tried to introduce a note of caution, but were drowned out in the growing chorus of acclamation. One of these more cautious officials was Ambassador Morehead Patterson, then U.S. Representative for International Atomic Energy Agency Negotiations. At the opening of the School of Nuclear Science and Engineering at the Argonne Laboratory in March of 1955, he welcomed a group of scientists from 20 countries that had come for training there and warned that, "Every promise has three dimensions, one of which is time. 'When' is a most important word. We will bring only disappointment and disillusion if people are persuaded that this is an easy and quick assignment. . . .

'The Sahara Desert just cannot be made to bloom next year.

The Siberian Rivers will not flow south the year after that.

The North Pole need have no fear that man will be able through the atom to melt the icebergs of the Arctic Circle in 1958.

Before we can run, we must learn to walk.'"*

---

*"Man's Benefits from the Atom," Atoms for Peace Manual, presented by Senator Alexander Wiley, June 21, 1955, (Washington, D.C.: U.S. Government Printing Office, 1955), p. 355.

A few weeks later Ambassador Patterson went into more detail for the benefit of a businessman's audience. He made the following points, which apparently few of them took to heart.

> The development of economically competitive atomic power is not necessarily a panacea for all the world's ills nor will it revolutionize the world's economy. In underdeveloped areas the availability of atomic power will not ease the basic problem of finding capital for economic development. Atomic power plants will not make obsolete modern efficient hydroelectric and steam electric plants. The principal causes for high foreign power cost to the consumer are the transportation of fuel, old inefficient plants, small units which are less efficient and economical than large plants, low rates of use with resultant high unit cost of power, high cost of investment capital, and power distributing systems. As opposed to a new conventional plant, an atomic plant would have a superior effect upon only the cost of transportation and production of fuel.
>
> In technologically advanced countries these facts are recognized. In some less advanced countries, however, there is a tendency to view United States proposals for international sharing of benefits of atomic power as a cure-all for basic economic troubles. We do not want to hold out false hopes. But while atomic power is not a panacea, it is a tremendously worthwhile objective and will make a great contribution in the future to world prosperity.*

It was only the last sentence that carried weight. By that date, some Atomic Energy Commissioners and staff may have begun to believe the rhetoric, or at any rate were now saying it themselves, and so was the industry. Ambassador Patterson, on the other hand, represented the majority view of the State Department, which was consistently stressing

---

*"International Cooperation to Harness the Atom for Peace--Where We Stand," speech to the Atomic Industrial Forum, San Francisco, California, April 4, 1955, in Atoms for Peace Manual, p. 360.

greater caution, walking first with atomic research activities and running later with nuclear power. That position is succinctly stated in an abstract of the Department's "Report on Nuclear Power Potential in India" of May 17, 1955.*

The report is an answer to Dr. Bhabha's statement in 1953 that "atomic energy offers the 'only chance' of raising the standard of living in India's and Pakistan's combined populations of 450,000,000." In the long run, the report said, technological progress might conceivably cut the capital costs of nuclear power plants to the level of conventional plants, and might cut the nuclear fuel charge considerably. But even if this were to happen, it would at most save about 5 mills per kilowatt hour or a little more than a fourth of power generation costs in the higher cost coal areas in India. Such savings would hardly be crucial in raising the standard of living of the 450 million people living in the subcontinent. They would not eliminate the major obstacles to India's growth. Moreover, the report stressed that the current capital costs of nuclear plants were much higher than those of conventional thermal plants and that given the low rate of capacity use in India this would outweigh any possible savings in fuel. It regarded as very unlikely that India would be able to build nuclear power plants as cheaply as the United States, but even if it could, and even if India got fissionable materials at negligible cost, the nuclear plants would have

---

*Reproduced in Addendum E

to achieve very high load factors to compete with conventional plants. Savings in any case would be limited to large power stations of over 100 megawatts, and smaller nuclear plants would have much higher generating costs. But India had little opportunity to use large plants. And finally, improvements in India's transportation system would enable it to exploit the large low-cost lignite deposits south of Madras, and that might lower relative coal costs in the next few years. All in all, the tenor of the report was sceptical. It placed sharp limits on the potential contribution of nuclear energy to India's massive problems of development, and the detailed comments raised major questions about how to compare nuclear and conventional electric power in a less developed country.

Resistance to the general euphoria and the slow pace of the State Department brought complaints and reprimands from the AEC on the inconsistency between U.S. domestic and foreign policies on the peaceful atom. The Department was accused of lagging behind and abdicating to private industry the responsibility for backing foreign reactor development and construction. It was not until 1962 that the Smyth Committee prepared for the State Department a policy statement which recommended giving firm support to the IAEA. (Smyth in 1953 had been one of the doubters.) Philip Mullenbach, looking back in 1962, summed it up:

> ...therewere exaggerated and misleading implications in the President's statement that nuclear power had been demonstrated technically (in the Nautilus and experimental units) and that this capability could be converted rapidly to economic use to meet the needs of "power-starved" areas. There are...no areas in the world that can be so described.*

---

*Philip Mullenbach, Civilian Nuclear Power: Economic Issues and Policy Formation (New York: The Twentieth Century Fund, 1963), p. 16.

In India there were very few doubters in the fifties. Bhabha's dominance of atomic matters made it difficult for dissent to be voiced,* and it was easy to be infected by Bhabha's own personal enthusiasm. What could anyone say to this distinguished scientist who in 1944 had predicted atomic electric power through fission, and who in 1955 with the same euphoria predicted that "a method will be found for liberating fusion energy in a controlled manner within the next two decades? When that happens, the energy problems of the world will truly have been solved forever for the fuel will be as plentiful as the heavy hydrogen in the ocean."**

Before Bhabha's rapt descriptions of the new world coming through atomic energy and Nehru's passionate advocacy, any attempts to recommend delay or to put forward more economic proposals or to suggest developing other technologies or sciences, such as biology or even bio-physics, sounded very dull and backward. Proposals of this sort had been made to both Bhabha and Nehru. Even at the first International Conference on the Peaceful Uses of Atomic Energy, some of the papers, notably that of the economist Edward S. Mason of Harvard University, had viewed the potential contribution of nuclear energy to economic development in the Third World with greater scepticism, and had in fact presented

---

* Anderson reports that "the financial member of the Indian AEC from 1962-66 (a person whose basic degree was in physics) said that Bhabha set the priorities, and he could check only cost-feasibilities." Discussion with S. Jagannatham, December, 1970. See also p. 69 of Anderson, op. cit.

**Proceedings of the First International Conference on the Peaceful Uses of Atomic Energy, Geneva, August, 1955. Op. cit. Volume 16, Record of the Sessions. p. 35.

a good deal of empirical data to evidence that even if nuclear electric power were to be cheap in the less developed countries, it would not be a key to rapid industrial progress and increasing per capita income. Indeed, a sobering discussion of the pseudo-correlation between per capita energy consumption and per capita GNP appears in Mason's contribution to that conference.

The second international conference had perhaps more cautionary papers on this subject, and in fact it featured an address by Francis Perrin, a member of the French Academy of Sciences and High Commissioner, Commissariat de l'Energie Atomique, who presided over the conference. While acknowledging that atomic energy "appeared to many under-equipped countries as a sort of royal road to prosperity," Perrin had this warning:

> In fact, in the near future atomic energy can play an important part in only a fairly restricted range of countries, which does not include those countries which are most lacking in industries and have the greatest need to raise their living standards. The countries which can take early advantage of atomic energy are those, already highly industrialized, which have insufficient traditional power resources to enable them to pursue their development; a development which, given the standards already attained, requires a considerable increase in the absolute level of electric power production. This is particularly the case sooner or later, for nearly all Western European countries.
>
> . . . .
>
> Under-equipped countries, whether with or without traditional power resources, cannot, it would seem, profit from the opportunities offered by atomic energy until they have gone through a preliminary stage of industrialization in the old way. If such a country has traditional power resources it would do better to try to make use of them, as the difficulties it must overcome (lack of capital, shortage of technicians) are even more marked in the case of atomic energy. And if an under-equipped country has no coal or oil deposits or water power that could be used economically, it would do better in most cases to import fuel (which would inevitably be expensive if it came from a long distance) and use it in

> traditional power plants, also imported, rather than import small atomic installations which are particularly expensive, and which would also require foreign technicians to a much greater extent. This will be the case so long as the degree of industrialization does not allow the utilization of large plants of several scores of megawatts, perhaps of even as much as a hundred. This conclusion remains valid even in the case of a country with uranium deposits, for atomic fuel costs relatively little in itself, and costs almost nothing to transport: furthermore, small atomic plants operate with enriched uranium which must necessarily have been prepared in a highly industrialized country.*

Perrin's estimate in 1958 that the minimum size for power reactors to be economic in most circumstances might be as much as 100 MWe understated the matter. His point is much reinforced by later experience. Today reactor manufacturers hardly bother to make reactors smaller than 500 or 600 MWe in capacity, and they are busy trying to sell 1,000 or 1,200 MWe plants to less developed countries (for example to Iran, the Philippines, etc.). Perrin's statement that the less developed countries would in any case be dependent on the advanced countries for enriched uranium was not exactly correct. They could, like Argentina, limit themselves to natural uranium reactors for generating power; or like India, they could concentrate most of their program on natural uranium reactors. However, this qualification of Perrin's statement is not an essential one, since in fact the difference involves simply a change in the form of dependence. The natural uranium reactors have meant a dependence on imports of heavy water or of heavy water technology, or both. Moreover, the

---

*Proceedings of the Second United Nations International Conference on Peaceful Uses of Atomic Energy, Geneva, September 1958, Volume I, pp. 40-41, Opening Remarks. Geneva, United Nations, 1958.

choice of heavy water reactors using natural uranium intensifies another problem that Perrin pointed out, namely the fact that less developed countries are capital short and nuclear energy is capital intensive. Capital costs of heavy water natural uranium reactors are higher than those of the light water slightly enriched uranium reactors.

The last two points in Perrin's speech should have hit home in India: the inevitable dependence on foreign technicians and foreign supplies of enriched uranium in developing atomic power installations, and the low cost of importing atomic fuel by comparison with the cost of mining and transporting it within India. Nehru, as we have seen, was immensely proud of India's local resources (especially of monazite sands, from which thorium could be extracted) and jealous of their protection. Along with Saha and Bhabha he was also devoted to the ideal of developing Indian scientists and engineers. At the time of this speech in 1958, however, negotiations were underway with Canada for two CANDU power reactors at Rajasthan (RAPP I and II), which would involve considerable Canadian technical help.

Perrin, one of the pioneers of nuclear energy, offers quite a contrast with Bhabha. Bhabha, however, did not budge in his own beliefs about the central role of energy in economic development, nor in his belief that nuclear energy was well adapted to the Third World and particularly to the circumstances of India. One of his 1958 papers not only repeated the point about GNP and per capita energy consumption being correlated, but used a table from the Mason paper which presented data on per capita GNP and per capita energy consumption, leaving out only Mason's analysis showing that the correlation didn't mean what it might seem to mean. In his lecture at the 2nd Conference, he recognized that some considerations did suggest that nuclear energy is in general more likely to benefit the advanced industrial countries, that, for example, the high capital cost of nuclear electric power was a problem for less developed countries where by definition capital is always scarce in relation to opportunities for its use, and where the demand for electric power is in general less likely to be concentrated enough to permit the large economies of scale and high load factors that are important in the nuclear generation of power. Bhabha nonetheless claimed that such factors would be overwhelmed in the case of India by other considerations, and he set forth a new comparison of the costs of nuclear and fossil fuel power in Bombay: Bombay is far away from coal fields; it has a comparatively large demand for electricity and Bhabha's figures in 1958 purported to show a range of possible costs for nuclear energy which at least at the low end almost exactly equalled the costs of conventional energy.

Bhabha's figures, however, were subjected in that same year to a very close and sophisticated scrutiny by I.M.D. Little, the British economist who had done outstanding work not only in basic welfare economic theory, but had been specializing in the economics of development and was the author of a study of the potential role of nuclear energy in the economic development of Italy. Little was not very impressed by the fact that the low end of Bhabha's range of atomic energy costs almost exactly coincided with the costs of conventional energy. He remarked that the same had been true of the British White Paper's cost comparisons in February, 1955, and that when the conditions assumed in those costs turned out to be in error, subsequent British estimates had simply changed the cost components and arrived at the same equality with the costs of conventional energy. "All this is rather a coincidence," he said, "and suggests a bias on the part of the estimators who may feel bound to get their estimates for nuclear energy down to the level of conventional energy."*

Little proposed therefore to examine the basis for Bhabha's figures. The capital costs, he found, were based on the assumption, among other things, that in spite of the considerable cost of transporting the reactor components and assemblies to India, the cost of the finished 150MWe station would be no more than that of such a station in England. Low Indian civil engineering costs, it was assumed, would offset the higher transport costs of the imported reactor.

On the other hand, these supposed offsetting savings in Indian civil engineering did not seem to apply in the case of the conventional power station. The costs of the latter were approximated by averaging

---

*"Atomic Bombay? A Comment on 'The Need for Atomic Energy in the Underdeveloped Countries,'" <u>The Economic Weekly</u>, Bombay, India, November 29, 1958, p. 1483.

the costs of six existing conventional stations in India which, however, were not comparable. Some were very far from port, adding to the costs, and they were small in size (averaging not much over 30 MWe) which also increased the costs, and this procedure tended to overestimate the cost of a 150 MWe conventional station. "I would think it very probable," Little commented, "that if a nuclear station can be built in Bombay for the same cost as in England, then a conventional coal fired station could be built in Bombay for the same cost as in England."*

In fact, the notion that the civil engineering costs to assemble and construct a reactor would be smaller in less developed countries in general, and in India in particular, than in advanced industrial countries is a durable myth which played a considerable role in the later evolution of the Indian program and its evaluation by the U.S. Atomic Energy Commission, and it persists in the estimates of costs of LDC markets developed in the International Atomic Energy Agency (IAEA). As we shall see, the U.S. AEC in discussing the economics of an American light water reactor in Bombay assumed this sort of cost saving, despite the fact that the Indian construction of the CIRUS reactor had already shown that it cost more to construct that NRX type of reactor in India than it had in Canada. Indian engineering labor is cheaper, but much less skilled, and the requirements for putting together nuclear installations are very exacting. And these phenomena, of course apply

---

*Ibid.

to other countries than India.* In short, Little's acute commentary on this point could be made stronger on the basis of subsequent actual experience.

Little's second point concerned Bhabha's assumption that the nuclear reactor would have an 80% load factor for 20 years. "This seems to have become a conventional assumption," he said, "but I have never seen it justified, and it raises difficult problems."** Little doubted whether an atomic station would be operated for 80% of the year for 20 years, and even if it were, one could not compare it directly with conventional power stations which operate quite differently—at very high load factors to begin with and then, as more efficient units come in to take the base load, at lesser load factors and over a long life time. Bhabha's comparison was biased in favor of nuclear stations. On the basis of such considerations alone, Little suggested that a comparison at a 65% load factor would be fairer and might even be close to the end of the range which favored atomic energy. Here, too, actual experience would only fortify Little's criticism. As of February, 1974 the actual capacity factors for the Indian reactors had been about 45%.***

---

*Richard W. Barber Associates. LDC Nuclear Power Prospects, 1975-1990: Commercial, Economic and Security Implications. ERDA Report 52, UC-2, 1975, II-15, footnote.

**Little, op.cit., p. 1483.

***Albert Wohlstetter, "Shall we Let India Separate Spent Fuel from the Tarapur Reactors?", February 24, 1976, See Addendum G. Footnote, page 1-169.

This point about the capacity factor is of great importance in estimating the comparative kilowatt hour costs of nuclear and fossil fuel plants in countries such as India. Since nuclear plants are more capital intensive, distributing these high capital charges over a smaller number of kilowatt hours than anticipated is likely to have a decisive effect. The irregular operation, the long periods out of operation, or in operation at less than full power, greatly intensify the problems of high capital costs which Little emphasized in his first point. India here was regarded as something of a test case. It was heralded as the most sophisticated of the less industrialized countries and the best able to handle the maintenance of a complex nuclear plant. The AEC files contain reports from General Electric, Kaiser and other observers that India was better able to handle such plants than any country outside of the United States. The experience in operation, however, does not bear out these high hopes, and inefficient use of a high cost plant can be critical for the actual comparative performance of nuclear and fossil fuel plants in the less developed world.

Little's third point also concerns the capital charges. Bhabha used annual capital charges of 9½% of the total capital cost, assuming interest rates of 4½% and depreciation of 5%. But, as Little pointed out, the function of the rate of interest in this connection should be to "reflect the true scarcity value of the long-term capital in the economy," and the 4½% interest rate was much too low to do that. Capital was obviously scarcer than in the U.K. Little suggested that for India "a 15% gross on capital is the absolute minimum needed for depreciation, plus an economic net return. I think one could reasonably argue 20%-25% in a country like India. (15% is probably about the average rate earned in industry in the U.K.)"*

Gross capital charges of 15-25% would have implied a rate of interest of 10% to 20% that better reflects the realities of the scarcity of capital in India and the many opportunities that existed for using such capital.

The choice of interest rate critically affects such comparisons as that between a nuclear and a coal-fired plant. Nuclear plants have larger capital costs and due to the wonders of compound interest, artificially low interest rates can easily blur the effects of such differences. The analysis of Tarapur done later for the AID agency by Burns and Roe took a range of interest rates, the highest of which was the lowest considered reasonable by Ian Little. At ten percent (the/ Burns and Roe high and the Ian Little low) the fossil fuel plants were superior. Moreover the impressive report of the Energy Survey of India Committee, done in 1965, only confirmed the wisdom of Little on this matter.

> The achievement of the solution will depend, secondly, on the right choice between more and less capital-intensive methods of producing the energy itself, or in this case, the capital equipment. We are convinced that in Indian conditions, where the facilities for complex capital projects are limited, excessive use of such facilities should be discouraged by a sufficiently high rate of interest. At the same time we think it is desirable, for reasons we shall discuss more fully in a later chapter dealing with the problems of pricing, that State Boards should aim to finance a considerable part of their investment out of their retained earnings and depreciation funds.

---

*<u>Ibid</u>., p. 1485.

> We, therefore, recommend that, in the planning of projects, a rate of return of 10% should be made the basis of all calculations.*

Among the stellar members and advisors of this committee of notables from the United States, Great Britain, Belgium, France and India was Dr. Bhabha.

Little concluded his perceptive analysis with a point of great importance, on the dangers of premature commitment, especially in a country that must husband its resources for investment in the future. It is a point of quite general application today, when in advanced as well as less developed countries there is a tendency to take a highly foreshortened view of the prospects of some quite uncertain technologies. He believed that the balance of cost would gradually swing more in favor of atomic energy.

> But that it might be good to have atomic energy in 20 years, or even in 10 years, is little reason to buy uneconomical plants from the U.K. or U.S.A. now. The U.K. may even itself have started too soon on too large a scale. And conditions in the U.K.--both economic and strategic--are immensely more favourable to atomic energy. The longer India waits, the more free benefits she will get from the immense investment which has been poured into nuclear physics and engineering in the U.S.A. and U.K. To put any of her own capital resources into buying the early products of this western research would seem to be a great waste of the very limited savings of the Indian people. As Dr. Bhaha says, electricity is in short supply in India. It is likely to go on being in short supply if one uses twice as much capital as is needed to get more. **

---

*Government of India, Report of the Energy Survey of India Committee, Government of India Press, New Delhi, 1965. p. 129.

**Little, op. cit., p. 1485

Some warning signals then about the immediate benefits of atomic energy had been sounded, and they were sounded again somewhat later, in January of 1961, at a symposium in Bombay following the opening of the CIRUS reactor. Both British and French scientists on this occasion again urged caution in expectations about the role of civilian nuclear energy. Professor Perrin returned to his theme of 1958. He stressed the recent improvements in France in the area of conventional power: the use of a new major source in natural gas piped under the Mediterranean from the Sahara. The relevance for India lay in the reserves of natural gas in Sui and Mari, across the Rajasthan border in Pakistan. In a similar vein, Sir Roger Makins, Chairman of the United Kingdom Atomic Energy Authority, dwelt on the "stretch-out" in England's nuclear power program following an overly pessimistic forecast in 1955 of conventional power potential and the initiation of an optimistic accelerated nuclear power reactor program. Conventional power costs had actually dropped, while long-term interest and development costs on the reactors rose. However, Sir Roger was optimistic about the nuclear future, and argued that the justification for building power reactors in a scientifically advanced country should not lie in economic considerations over the short or medium term. Each country should build its own reactor--given the vast areas of the unknown in nuclear power--and thereby through its own experience and knowledge determine what would be an economic program of nuclear power generation. A scientifically equipped nation could profit by its own mistakes. Sir John Cockcroft, a member of of the U.K. Atomic Energy Authority and U.K. representative on the U.N. Scientific Advisory Committee spoke after Sir Roger Makins, warmly endorsing this point of view.

But on the Indian view, coal, hydroelectricity, oil, and natural gas continued to have few attractions compared to nuclear energy. According to the report of the American consul in Bombay, Nehru at the opening ceremony on January 16 attacked those of "limited vision and restricted thinking" who questioned the economics of a reactor program for India at this stage of her economic development."* "Referring to India's 'epic struggle to revolutionize the life in her 550,000 villages' he asserted, 'we do not want tomorrow to slip out of our hands by getting entangled with the problems of today.'" The press reported his speech as "one of the most scathing" and "one of the fightingest" in his career.** In this area, at any rate, Nehru preferred to deal with the future <u>rather</u> than the present.

---

*Report of the ceremonies by Sidney Sober to the Department of State, January 24, 1961, "Atomic Energy: Symposium on Nuclear Power, Bombay," Typescript. See Addendum C, p. 1-133.

**<u>Ibid</u>.

THE CIRUS, THE PHOENIX, AND THE ARGUMENT OVER SAFEGUARDS

The ceremonies connected with the dedication of the CIRUS are particularly interesting today, since the CIRUS has gained international notoriety as the source of plutonium for the first Indian nuclear explosion in May of 1974. Besides the CIRUS which was a very large (40 megawatt) thermal research reactor, several other facilities were inaugurated: Zerlina, a "zero energy" small natural uranium-fueled research reactor, a uranium metal plant, a fuel element fabrication facility to produce natural uranium fuel for the Zerlina and the CIRUS, and a heavy water reprocessing plant to reconcentrate downgraded heavy water for re-use in the Zerlina and the CIRUS. Some 48 foreign officials attended the events. The U.S. delegation consisted of Commissioner Robert E. Wilson; Dr. I.I. Rabi, the U.S. representative to the U.N. Scientific Advisory Committee; Dr. John A. Hall, Assistant General Manager for International Activities of the AEC; and Dr. Robert A. Charpie, Assistant Laboratory Director for Reactors of the Oak Ridge National Laboratory. Canada, France, Great Britain, and Brazil were represented and from the Soviet bloc: the USSR, the People's Republic of China, Hungary and Czechslovakia. At this time APSARA, India's first research reactor which had been shut down in August 1960 for repairs and improvements was also restarted. Details of its construction and the scientists associated with it are given in Addenda A and B.

The State Department Report of the ceremonies and its catalogue of existing facilities in India are reproduced in detail as Addenda C and D. The extent of the program is indeed impressive. As the report mentions, "India by this date had the beginnings of a comprehensive nuclear research and power program, including facilities for surveying and exploratory drilling for the uranium- and thorium-bearing ores available in the country; for mining and extracting; for producing and reprocessing fuel elements and also heavy water; for engaging in effective nuclear research and for making radioactive isotopes for other research." The heavy water referred to here was not simply the small reconcentration plant at Trombay, but the heavy water production facility at Nangal in Punjab, scheduled to go into operation at the end of 1961, and actually functioning in 1963. Its annual production rate, it was hoped, would be 15-20 tons of heavy water, though the original goal had been 5 or 6 tons. This plant continues to be referred to as "purely Indian"--with understandable national pride and with some effect on the controversy about the Indian nuclear explosive. Nonetheless an American firm, Vitro International, was retained as consultants and architect-engineers for its construction, and Linde of West Germay was responsible for supply, erection and commissioning.*

Also of critical interest today is the used-fuel reprocessing plant, known as Project Phoenix, described initially as "a small pilot plant for the recovery of plutonium from irradiated fuel elements" from the CIRUS reactor. In fact the Phoenix was rather large. Its capacity (100 MTU per year) exceeded the original advertisement. It was here that the plutonium for the Indian bomb was extracted. Bhabha had decided to construct this plant in 1958, and as we have mentioned earlier, construction began in

April, 1961. Bhabha's motives in setting up this plant have been the subject of some controversy, even among Indian scientists. In a memorial piece after his death, his successor as director of the Tata Institute, Professor M.G.K. Menon, tried to put this "in the right historical perspective." He quotes from a speech of Dr. Bhabha of January 20, 1957, on the occasion of the inauguration of the Atomic Energy Establishment at Trombay:

> There is another very important consideration which should be mentioned. It is likely that the future more advanced and efficient types of atomic power stations will use concentrated atomic fuel, such as uranium 235, uranium 233, or plutonium, rather than the naturally occurring uranium. If we are not to depend on the import of such fuel from abroad, and not to build a gaseous diffusion plant, involving an enormous expenditure and technical effort, it is necessary for us to start producing this fuel *now* by converting natural uranium into plutonium, and thorium into uranium 233 in atomic reactors. If we are, therefore, not to lose further ground in the modern world, it is necessary for us to set up some atomic power stations within the coming five years, which will produce plutonium for our future power reactors, in addition to producing electricity now.*

Dr. Bhabha's explanation suggests a rather hazy view of the connection between the present "now" and the future. Like Nehru, he wants to start separating plutonium "now" when it will not be needed until much later, even though, as in all less developed countries, capital for investment is extremely short, and premature investment simply wastes it. Again in his opening address at the inauguration of the CIRUS, Bhabha remarked:

> Work is in hand on the construction of a small plant at the northern end of this site for the reprocessing of the used fuel elements, the separation of radioactive fission products, and the extraction of the valuable plutonium or uranium 233 contained in them....Since India

---

* M.G.K. Menon, *op.cit.*, p.434. Italics added.

> has the world's largest deposits of thorium in very high grade ore, it is essential that we should find a means of using the thorium for power production. This can only be done if we have at our disposal a concentrated fissionable material like plutonium which is naturally generated in the uranium fuel elements used in atomic reactors. The only other way of obtaining such concentrated fuel, namely by the extraction of uranium 235 from natural uranium, is extremely expensive both in capital and in running costs and consumes large amounts of electricity. We have, therefore, decided to follow the more economical way, of using the plutonium produced in power stations fuelled with natural uranium *.

"Economical," perhaps, in some very dubiously restricted sense--it was less uneconomic than investing in an isotope separation plant, but it was hardly the result of sober and realistic economic calculation that could convincingly show that for India at the time there was a positive present value in such a highly uncertain and very long term investment in a facility for producing concentrated fissile material, and then stockpiling it.

Menon's historical perspective stresses once again the need for India to be ultimately self-sufficient in energy. And that overall objective is stated clearly at the end of the State Department report of the ceremonies--though the present tense of the verb makes the time dimension much less clear.

> The programme is, briefly, to set up in stages three types of power reactors which, in addition to producing electricity, also produce fuel for other reactors: in the first stage natural uranium after appropriate purification is fed as fuel to a reactor; when this uranium fissions the irradiation converts some of the uranium 238 into plutonium - another element which, like uranium 233, does not exist in nature and can also be used as a fuel. In the second stage, when sufficient plutonium has been produced, it is used as a fuel in another type of reactor,

---

*Ibid.

> and surrounded by thorium; as a result of irradiation, some of the thorium is converted into uranium 233. In the third stage, when a sufficient quantity of uranium 233 has been produced, it is used as fuel in yet another type of power reactor in which thorium is again introduced; the thorium is again converted into more uranium 233 and in fact produces more than is actually consumed. This type of reactor is known as a "breeder" reactor and all that is required to feed it is additional thorium - of which India has a super-abundant supply.

The three stage plan which Bhabha had had in mind since the mid-1950s and which is elaborated in this State Department report had a certain plausibility. It was plausible in particular if one considered only some fundamental concepts of reactor physics and ignored the practical economic details of how to develop a highly sophisticated and experimental form of electric power in a largely unindustrial country with slender human resources for research and development. India's monazite sands are rich in thorium, and it was clear in concept that thorium-232 could be used, as a "fertile" material, to generate the fissile uranium-233 in a slow breeder.* Unfortunately, the commercial operation of an economic breeder, fast or slow, even today is decades from reality, and surely was very far beyond the capability of India to plan for in the 1950s.

Research and development of the breeder in advanced countries has concentrated on the liquid metal fast plutonium breeder. Much less effort has gone into the slow or fast thorium--uranium-233 breeder. It was hardly likely that India could develop the thorium breeder on its own, and still less likely that this hazardous use of its very scarce capital including its scarce professional human capital, would be prudent. On the other hand, even if the advanced countries had themselves undertaken a massive long-term R and D spending for the thorium breeder comparable to the billions it has invested in the fast plutonium breeder, it was improbable that India could

---

*Bhabha's colleagues argued in support of his plan in a technical paper at the Second International Conference. After 1980, they believed, a few thousand MWe per year would have to be added annually. Therefore uranium reserves were inadequate. "It is thus necessary to seek ways of meeting future power demands using thorium alone." Since thorium is not fissile, U-233 reactors would be required, and "these reactors will have to be breeders" to meet the growing electrical demand. M Dayal, S.R. Paranjpe, N.B. Prasad, and B. Singh, "Study of Fuel Cycles with Reference to a Power Programme," Proceedings of the Second International Conference, op. cit., P/1642, p. 184.

have made more than a marginal contribution to that development? And would it have been wise for India to start attempting a sizeable contribution that early? The matter is important because such R and D programs are likely to carry a country rather far toward the acquisition of bomb material. Their economic aspect needs particularly skeptical scrutiny therefore, and the economics of research and development are in general extremely difficult to analyze, precisely because of the enormous uncertainties as to both costs and benefits. On the other hand, that in itself says a good deal about the inappropriateness of such gambles for countries that are extremely short of capital.

The final stage of the Indian program, which called for the operation of breeder reactors, was a most questionable goal. Even the earlier stages of the Indian plan were highly questionable from the standpoint of practical power economics. The first stage mentioned in the State Department's account of India's plans as of 1961 was the production of plutonium in a heavy water natural uranium reactor for use as fuel in a second stage heavy water moderated converter reactor. This second stage would apparently generate uranium-233, though possibly with a regeneration ratio of less than unity, that is, it would not generate as much fissile material (uranium-233) as it would consume (of plutonium). The transition to a thorium-uranium-233 fuel cycle, however, did not require plutonium. A fissile material could have been planned to be enriched with uranium-235. The use of enriched uranium cores was in a more advanced state of development by that time, and the cost of reprocessing spent uranium fuel to derive plutonium could only be hazarded. Nonetheless, Bhabha's plans to avoid the use of enriched uranium were not inconsistent with the thinking of the British at the time who also talked of reprocessing as a potentially cheaper alternative than enriched uranium. A paper by British experts for the second International Conference in 1958 suggested reprocessing costs, including conversion to plutonium oxide, of three pounds per kilogram.* However, this estimate was extremely uncertain and, as we now know, understated the costs by at least one and possibly two orders of magnitude. But in any case the entire program involved large uncertainties as to the feasibility and timing of the successive stages. For, besides these three stages using three different kinds of power reactors, Bhabha's program involved a prior stage using the research reactor CIRUS to begin generating the plutonium for this highly uncertain future. That plutonium could conceivably have been stored unseparated in the spent fuel, but Bhabha apparently proposed to start separating plutonium from the CIRUS fuel long before the first stage power reactor could be in place; only in the second near-breeder stage are the power reactors supposed to use plutonium as fuel.

It did not occur to American observers of the Indian program at that time to note that (1) the Indian program was based on quite tenuous economics and vague research and development and production plans, and (2) that it could yield stockpiles of highly concentrated fissile material quickly convertible for use in explosives at the very earliest stages of the program--long before power was likely to be generated--and that such stocks would be a regular accompaniment to the generation

---

*N.L. Franklin, J.M. Hill, C.A. Rennie, and J.C.C. Stewart, "Economics of Enrichment and the Use of Plutonium and Uranium-233," Proceedings of the Second International Conference on Peaceful Uses of Atomic Energy, Vol. XIII, pp. 273-281.

of power when the program was fully effected. American inattention here had a good deal to do with the fact that America's own nuclear plans accepted without question that the future of nuclear electric power depended on the conversion of non-fissile but "fertile" atoms (uranium-238, thorium-232) into fissile atoms (plutonium-239, uranium-233). For example, this assumption appears in one of the most used atomic energy handbooks, first published in 1950, Samuel Glasstone's Sourcebook on Atomic Energy.

> The long-range future of the nuclear energy industry must therefore depend on the efficiency of converter reactors in which plutonium-239 (or uranium-233) is consumed and is, at the same time, regenerated from uranium-238 (or thorium-232).*

Menon's attempt to justify Bhabha's early interest in reprocessing does not mention the early American interest in the breeder nor the early American belief in the necessity of using plutonium fuel which was in turn based on the supposition that there was an extremely limited supply of uranium available in the world.**But the interests and beliefs of American scientists certainly exerted some influence on Indian decisions. Menon is trying to protect Bhabha from the accusation that his motive in building a reprocessing plant in advance of the need for plutonium was to bring about a military nuclear program for India. He points out that both of the statements quoted above from Bhabha were made before the hostilities between China and India and before any Chinese nuclear explosion. "The decision concerning the extraction of plutonium was, therefore, taken at a very early date and was not linked with the possibility of its being material suitable for nuclear weapons."***

---

*Samuel Glasstone, Sourcebook on Atomic Energy, Third edition, 1967, Van Nostrand Reinhold Co., New York, p. 573.

**See Monograph #2, "Economics of the Plutonium Fuel Cycle and U.S. Policy on Reprocessing."

***Menon, op.cit., p.434.

Vince Taylor, PAN Hearings

There is other evidence to support Menon's defense of Bhabha. The construction of the reprocessing plant was never secret, contrary to some newspaper accounts immediately after India exploded its first nuclear device. Bhabha had discussed its design in 1958 with U.S. scientists, using the blueprints for the Purex process released by the U.S. AEC (the process for deriving plutonium for the first American bombs). An American firm, Vitro International, was responsible for variations in the design of the Indian facility, a transfer of technology which apparently required no license on the part of the American government. (Ironically, the Indian government then made their particular design Indian-proprietary, even the parts designed by Vitro,* with no record of protest from our government.)**Bhabha's successor had arranged with AID for four Indian scientists to receive special training in reprocessing under the AID loan for the Tarapur project. A full description of the plant occurs in the Proceedings of the Third International Conference on Peaceful Uses of Atomic Energy, held in Geneva August 31 to September 9, 1964. The two authors, H.N. Sethna (then Chief Chemical Engineer and now head of India's Atomic Energy Commission) and N. Srinivasan, made quite clear that the plant was built to handle irradiated fuel elements from the Canada-Indian Reactor, CIRUS, and proceed to describe in detail problems connected with these fuel elements. Reports and

---

*Letter of February 14, 1963 to Mr. Robert Slawson, Division of International Affairs, U.S. AEC, from Paul N. Fraser of Vitro International reporting that Mr. H.N. Sethna, then Chief Chemical Engineer of the Indian AEC in Trombay, had refused permission to give information on the "status of the reprocessing facility being constructed by the Indian Atomic Energy Department at Trombay, India" to the U.S. AEC.

**The plant is described in September 1973 as "designed and built by BARC personnel" in "India Atomic Energy Progam", (ERDA files, no author indicated) and again in Sept. 1975, in what is apparently an annual review.

analyses in the ERDA files at that time also suggest that a plan to separate plutonium for later civilian use as fuel was accepted as quite "normal".

The conception of "normality" in these areas was lax and tenuously based on anticipations as to the economic prospect of various civilian fuel cycles and a nearly total amnesia about the military dangers. There was a notable vagueness among the Indians and a remarkable lack of curiosity among Canadians and Americans about exactly what purpose would be served and when, by the plutonium separated from the heavy water reactor fuel in CIRUS. CIRUS, as we have said, is a research reactor using natural uranium and requiring therefore no extra fissile material by way of enrichment, neither plutonium nor extra uranium-235. Reprocessing and recycling were not part of any reasonable norm for its fueling. At the time the decision was made to build the Phoenix plant to reprocess CIRUS fuel, the Indians had no plans for using light water moderated power reactors with slightly enriched uranium. Their ambitious first phase was modelled on the Canadian program, using only natural uranium reactors, cooled and moderated by heavy water. Nothing in that norm required the separation of plutonium. And indeed the Canadians themselves do not have a reprocessing plant. They have planned to dispose of spent uranium waste directly, without reprocessing.

Moreover when the Indians did decide to introduce at Tarapur one twin boiling water reactor installation, (a) this was scheduled to come on line years after the Phoenix reprocessing plant was in operation, (b) it was planned to use fuel slightly enriched in uranium-235, and (c) the Phoenix plant was not equipped to reprocess such light water reactor fuel. Nothing in short should have suggested that the Phoenix reprocessing plant was required by any reasonable norm for the Tarapur light water reactors or the Rajasthan or Madras heavy water reactors. Ian Little's point about premature investment in nuclear power applies with even greater force to investing scarce resources in nuclear material stockpiles that have no projected use until later generations of nuclear energy come into being--at the most optimistic guess--after several decades.

It is worth spelling this out. The Indians have suggested rather casually that their nuclear explosive program cost them very little. Sometimes they say $10 million, sometimes $400,000. If one considers seriously the extra cost of getting the plutonium beyond that justified by the strict economics of what was an optimal investment program in electric power, it is clear that all such numbers greatly understate the real costs to the Indian people of the work that led up to the 1974 explosion. For the Phoenix plant itself, the costs of its installation and operation can hardly be justified on grounds of its civilian use. The Indians named a very low figure in 1964 for the installation costs--eight million dollars. However even neglecting inflation since then, the figure is certainly misleading. Government cost estimates in general, not only in India, are quite unrevealing. They do not as a rule make clear what is included and what is not, and in India especially the methods of accounting are not easily checked.* A good deal of evidence suggests that in spite of the lower wage rates of labor in the less developed countries, and in India in particular, the total costs-in-place of such sophisticated installations are substantially higher there than in industrialized countries such as the United States, Canada, the UK and France. According to the Barber Report** they are some 15% to 20% higher than in the United States, and this conforms very well with the actual experience of installing

---

* For an example of the casual treatment of nuclear costs in India, see the recent study by O. Marwah, Conflict System, Security Environment, and Policy Making for Defense, Ph.D. thesis, University of California, Berkeley, 1976, and also his article in [illegible]

**Richard J. Barber Associates, Inc., LDC Nuclear Power Prospects, 1975-1990, op.cit., pp. II15-16. The TVA indicates that for well established technologies, as in fertilizer plants, the costs would be 25% more in the LDCs than in the U.S. A study of Korean nuclear power costs by J.H. Cha indicates that nuclear powerplants in place in Korea cost 15-20% higher than in the U.S.

the CIRUS reactor in India, where the costs were actually double those of installing the Canadian NRX (on which the CIRUS was modelled) in Canada. A prudent estimate would take U.S. costs for constructing a given plant as a lower bound for the costs of constructing the same plant in India.

The cost for a 100 MTU reprocessing plant today in the United States is on the order of $75 to $100 million. The Japanese reprocessing plant, Tokai Mura, will apparently have a capacity of 100 MTU per year, which was less than expected, and it will have cost about $200 million, which was a good deal more than expected. These costs are for facilities capable of reprocessing light water reactor fuel, which is more difficult than heavy water reactor fuel. But it is clear that a reasonably inclusive estimate of the real costs of the Phoenix in today's dollars would be much closer to $100 million than to eight. That estimate considers only the cost of the plant itself and says nothing about the cost of producing the plutonium and of stocking it and, most important, nothing about the cost of stocking it for decades, while waiting for a breeder or near-breeder. Since the plutonium stocks would have no essential civilian utility before the near breeder arrived, the real costs of stockpiling it should reflect the opportunities lost for investing these resources elsewhere in the capital-short Indian economy. Such opportunity costs are measured by the real rate of interest, and Ian Little suggests that at a minimum in India that rate was 10% and arguably on the order of 20%. Since an interest rate of 10% implies a doubling time of something over seven years and one of 20% a doubling time of a little less than four years, then the real costs of investing in the production of plutonium and stockpiling it for several decades are likely to be a very large multiple of the original sum invested in the reprocessing plant.

In short, the Indians may have spent initially nearly $100 million on their plutonium separation facility, but that was only the beginning. The plant cannot be expected to have any genuine civilian utility in the nuclear fuel cycle for many decades, and the thorium breeder will probably not be in commercial operation in India before the end of the century. So the actual costs are many times greater than these initial costs, when one consders the opportunities lost.

Of course it might be argued that scarce though capital is in India, and high though the return to its use might therefore appear to be, in fact the Indians would manage these alternatives so badly that they would return considerably less. However, that is only to say that the usual Indian practice of investment is as cavalier and casual as the decision on the plutonium separation plant illustrates. It does not say that there are not opportunities for wiser investment, and if opportunity costs are to reflect the sacrifices made by unwise decision, it is these opportunity costs that should be considered.

These reflections on the Indian economic experience ought to give us pause, when making future arrangements with other developing countries that request our aid in the field of nuclear technology, and in making estimates about what aspects of nuclear power will be most beneficial to their economic development.

Menon's defense of Bhabha also has important implications for U.S. policy against proliferation. As we have said, there is no reason to question his assertion that Bhabha began the funding and completed the construction of the reprocessing plant with no intention whatsoever of using it for separating plutonium for a nuclear explosive. In fact, that account is entirely consistent with the evidence that shows that Bhabha began to mention nuclear weapons or other nuclear explosives only after the Chinese defeat of India in the Himalayas in 1962, and that his interest intensified in 1964 after the Chinese explosion. But this sequence of events bears on the most interesting considerations affecting policy as well as on the always worrisome difference and connection between capabilities and intentions, and the problems of intelligence on the two. For if, as seems entirely likely, the high Indian officials had no intention of using the Phoenix separation plant and the CIRUS reactor to obtain plutonium for an explosive, nonetheless their decision to get the CIRUS meant that by the early 1960s they would have greatly advanced towards the capability to do so. And this capability, once acquired, in turn made it easier for the Indians to alter their intentions after the humiliation of military defeat by a regional adversary -- an adversary moreover that had achieved a successful nuclear weapons program.

The relations between capabilities and intentions are subtler than is suggested by the usual discussion of them. Frequently we are told that it is not capabilities, but intentions that count. The dichotomy of course is misleading. We are interested not simply in <u>present</u> intentions, but in future ones as well. And the closer the approach to a nuclear explosive capability, the less costly and time consuming and visible the rest of the path, and the more likely a country is to be impelled to go all the way by events such as a military defeat or the acquisition of nuclear weapons by an adversary, or the lapse of some military assistance or guarantee by a friendly power, or some combination of these. Future intentions ought to concern us quite as much as present ones. In fact India did suffer a defeat, and it did see the U.S. reduce its military assistance in the mid-sixties. Even if in 1958 the Indian government had been, as it was not, as pacifist as Gandhi, policy makers could hardly assume that it would continue to be in 1965. Policy against proliferation has to consider not only the possibility of unpredictable, adverse events that might intervene, but also the necessity to discourage the growth of capabilities whichwould make non-weapon states more liable to change their minds about continuing to be non-weapon states after adverse events have occurred.

A brief look at the negotiations between Canada and India for the CIRUS and the opening U.S. talks on the Tarapur project confirm the impression that the initial vision of nuclear research and its fruits, in particular the development of nuclear power for electricity, belongs to an age of innocence or at least amnesia so far as the dangers of proliferation were concerned.

Negotiations between Canada and India for the CIRUS reactor began during 1954. It was to be a modified version of the Canadian NRX reactor which had been operating at Chalk River since 1947. It required ten tons of natural uranium fuel, half of which would be fabricated by Canada, and half by the Fuel Element Fabrication Facility at Trombay, and was to be moderated by 21 tons of heavy water from the United States. Sea water provided the cooling system. The reactor was designed (1) to establish the different characteristics of materials for other reactors under actual operating conditions of temperature, pressure and radiation field; (2) to provide for fundamental research in biology, chemistry, metallurgy and physics, "particularly in experiments on breeding the thorium, which India has in abundance, into fissile U-233";* (3) to produce radioisotopes; and (4) to provide training and experience for DAE personnel.

---

*From the description of the opening ceremony dedicating the CIRUS. See Addendum C., p.4.

Financing under the Colombo Plan was based on a first cost estimate of $14 million, of which Canada would supply $7.5 million. Canada also paid for training visits to Chalk River for a number of Indian scientists and engineers. As described in 1956,

> Canada's participation in the project consists of furnishing the atomic reactor and the steel for the rotunda which will house it, designing the reactor, its foundations and the steel rotunda, and supervising the engineering and the erection of the reactor at Trombay. The government-owned Atomic Energy of Canada Limited will be responsible for these activities, and will be assisted by the Shawinigan Engineering Company Ltd. of Montreal, which will actually design the reactor and its foundation and rotunda, and will provide personnel for the engineering services and for supervising the erection at Trombay. Parts of the reactor will be manufactured at different places in Canada as well as in the United States and the United Kingdom.*

This was Canada's first sale of a nuclear reactor to a foreign country, and the negotiations were conducted in an atmosphere of trust. Canada had been associated with India in peace-keeping efforts in Korea and in manning international control commissions in Southeast Asia. It had also befriended India early in the nuclear field by sending a ton of crude uranium oxide to Dr. Bhabha in 1947. Bhabha had wanted to get his scientists started early on mineral experiments, and Canada had complied with his request after getting British and American approval. All three countries regarded the shipment as possible insurance of future access for the West to India's thorium supply.**

---

*U.S. Embassy Ottawa Dispatch 760 of May 1, 1956 to Department of State, "Canadian Indian Agreement on Atomic Reactor Project."

**Barrie Morrison and Donald M. Page, "India's Option: The Nuclear Route to Achieve Goal as World Power," International Perspective, July-August, 1974, p. 25.

The agreement on the CIRUS was drawn up before the existence of the IAEA, and before the United States had settled on its preferred phraseology for an agreement on cooperation. However, the agreement between Canada and India did contain the sentence, "The Government of India will ensure that the reactor and any products resulting from its use will be employed for peaceful purposes only." Bhabha insisted that India's word was a sufficient guarantee and refused to consider the question of safeguards except obliquely in Article XI, which stated,

> It is the intention of both Governments that the fuel elements for the initial fuel charge and for the continuing requirements of the Reactor will be supplied from Canada save to the extent that India provides them from sources within India. Arrangements for the provision of the fuel elements to India from Canada will be agreed upon by the two Governments before the Reactor is ready to operate; if an international agency acceptable to both Governments has come into being or is in prospect at that time, the terms of such agreement will be in keeping with the principles of that agency.

There were some misgivings, since Nehru had condemned the principle of international inspection or control of nuclear raw materials and production in a speech to Parliament on May 10, 1954. But Canada was willing to accept the vague promises about peaceful uses only. It was anxious to conclude a deal that would offset India's acceptance of Soviet steel-mills, and that would publicize Canada's own contributions to the development of nuclear power by the use of heavy water and natural uranium.

The United States was similarly blithe in its contractual arrangements for the sale of heavy water to India for use in the CIRUS. An agreement of March 16, 1956, signed by Homi J. Bhabha and Lewis L. Strauss, provides in Article 9 that "the heavy water sold hereunder shall be for use only in India by the Government in connection with research into and the use of atomic energy for peaceful purposes, and shall be retained by the Government, or by other parties authorized by the Government to receive it, and not resold or otherwise distributed."* The U.S. AEC had decided to sell the heavy water in February 1955, a year earlier. Part of the interval between decision and actual agreement was spent in a joint effort with the Canadians to get the water and the reactor safeguarded, but to no avail. Construction on the reactor proceeded, while attempts to institute safeguards were continually turned aside.

Atomic Energy of Canada Limited had originally planned to complete work by 1957, but this completion date was delayed to late 1960. The costs also doubled.** The Department of External Affairs told the State Department about these difficulties with the Indians, but apparently their experience had little influence on the decision of the United States to conclude an agreement for the two Tarapur reactors, and not a great deal on the Canadian negotiations on RAPP I and II. Indian resistance to safeguards became one of the chief obstacles to conclusion of the U.S.-Indian Agreement on Cooperation.

THE ARGUMENT OVER SAFEGUARDS

Indian resistance to safeguards in 1956 was phrased in terms of Indian sovereignty and justified in terms of Bhabha's plans for an eventual breeder. Bhabha was quite explicit on both points. At the Conference on the Statute of the International Atomic Energy Agency (IAEA), he explained:

> In order to alleviate the long-range power problem, we have not only to burn the uranium-235 contained in natural uranium, but we have to utilize all the uranium and thorium as is possible through the breeding process. It is, therefore, essential that the long-range atomic power programme be based on atomic power plants which breed new fissionable material from source material. Since such power plants use special fissionable material, it is necessary to produce this fissionable material in the earlier power plants for use in the power plants which are to come later in the programme.***

---

* The agreement is reproduced in Hearing on S. 1439, Export Reorganization Act of 1975. Joint Committee on Atomic Energy, June 22, 1975, USGPO, Washington, D.C. 1976, p. 14.

** The Canadians have noted that the construction of an NRX type of reactor there costs twice as much ($30,000,000 vs. original estimate of $14,500,000) and took over twice as long." Appendix A of AEC trip report, February 29-March 18, 1960. Typescript in ERDA files. open

***IAEA/CS/OR.7 48.

Therefore, he argued, "We consider it to be the inalienable right of States to produce and hold the fissionable material required for their peaceful power programmes."*

For his distant panacea of the breeder, Bhabha maintained that there was a large present value in India's stocking plutonium, and he therefore rejected the draft proposal which gave the IAEA the power "to approve the means to be used for chemical processing of irradiated materials recovered or produced as a by-product, and to require that such special fissionable materials be deposited with the Agency except for quantities authorized by the Agency to be retained for specified non-military use under continuing Agency safeguards."** "In our opinion," Dr. Bhabha continued, "the present draft gives the Agency the power to interfere in the economic life of States which come to it for aid. . . . It therefore constitutes a threat to their independence, which will be greater in proportion to the extent that this atomic power generation is developed through Agency aid."*** Bhabha also objected to the phrasing of Article XII of the Statute defining the Agency's rights and responsibilities, and proposed a qualifying amendment, the addition of the somewhat vague phrase, "to the extent relevant to the project or arrangement."‡ The amendment still stands, an example of the numerous loopholes which the Indians wove into the fabric of the IAEA rules.

---

* *Ibid.*

** IAEA/CS/OR/28, p. 6.

***IAEA/CS/OR.7, pp. 49-50.

‡ Ibid. p. 52.

The United States had argued strongly for accountability for all source and special fissionable materials used or produced in Agency projects.

> The very name "source materials" indicates the fundamental role that the material plays in the utilization of atomic energy. It is the only material from which either the fissionable isotope Uranium-235 can be separated or from which the fissionable isotope Plutonium-239 or Uranium-233 can be manufactured. Thus, practically every atom of the non-fissionable source materials uranium and thorium is potential fissionable material. . . . No other presently known elements are useful and practical for this purpose.*

Bhabha protested equally strongly against accountability of source materials. The final compromise reached in the IAEA Statute retains the principle of accountability of source materials, but allows the States to keep the "special fissionable materials recovered or produced as a byproduct," under continuing Agency safeguards, in such quantities as they could use "for research or in reactors, existing or under construction."

Bhabha was clearer than many American officials are today about the fragility of any system of safeguards. "We mislead ourselves," he said, "and obscure the problem by thinking that a 100 percent foolproof system of safeguards can be found which will eliminate the clandestine manufacture of weapons."** He gave as an example the use a country might make of scientists trained in the field of nuclear energy.

> A country not having any trained personnel may receive Agency assistance, with all its safeguards, and in the course of the years build up a large number of trained scientific and technical personnel. There is nothing to stop that country, if it is so inclined, from then switching over its personnel to military programmes entirely independent of the Agency.***

---

* IAEA/CS/ OR.37 p. 21 Mr. Wadsworth

** IAEA/CS/ OR.28 p. 56.

***IAEA/CS/OR.28 p. 58.

But Bhabha combined with this hard-headed view a passion for asserting Indian independence and the need for any IAEA control to be completely "objective and non-discriminatory." "If . . . a large part of the world is subject to controls and the other free of them, we will stand on the brink of a dangerous era sharply dividing the world into atomic 'haves' and 'have nots' dominated by the Agency. Such a division would in itself, by creating dangerous tensions, defeat the very purpose of the safeguards, that is, to build a secure and peaceful world."* If safeguards are to be applied to a non-weapon state, then they must be applied to the weapon states. Anything else amounts to a "new form of economic colonialism."**

The Indians have been the principal battlers for "equity" or equality in nuclear matters from the earliest negotiations. Their appeal struck a responsive chord among officials and intellectuals in the weapon states. But looked at dispassionately, it is clear that there are limits to the equality that is feasible between weapon and non-weapon states, if we are to take non-proliferation as a serious objective. By the mid-1950s both the United States and the Soviet Union had explicitly recognized that there was no practical way--now that weapons had been made and stored in large numbers--of assuring total nuclear disarmament of the weapons states. Any attempt to limit the number of new countries acquiring nuclear weapons implies then a durable distinction between weapon and non-weapon states. There is no getting around that. Speeches about the desirability of total nuclear disarmament, not to say general

---

*IAEA/CA/OR.7 p. 48.
**Ibid.

and comprehensive non-nuclear and nuclear disarmament, are understood to bewail the fact of nuclear armament rather than to constitute a program for its total elimination. Moreover, the reduction of the nuclear stockpiles of the weapon states by half or by nine-tenths, or whatever, short of their total elimination, will not change that fact. It will not alter the existence of a distinction between nuclear weapon states and non-nuclear weapon states which is a distinction in kind, not a distinction in degree. The insistence on the elimination of such a distinction in practice means the acquisition of nuclear weapons by the non-weapon state. And today Pakistan talks of general and comprehensive disarmament in much the way that India did in the 1950s and 1960s, as if it were the only fair alternative to acquisition of nuclear weapons. There is a long history of such invocation of disarmament clauses to rationalize armament. The disarmament clauses in the Versailles Treaty were used by Hitler in precisely that way.

Now as then such arguments appeal to the sense of fairness and the sense of guilt of those more favored. The Indians elaborated many variations on this theme of equality and wove it into their bilateral agreements as well as into some of the basic statutes of international organization. In the case of safeguards, the plain purpose in a non-proliferation agreement is to prevent or discourage or warn about a non-weapon state's approach to manufacture of nuclear explosives. Safeguards have to do with seeing to it that a non-weapon state does not become a weapon state. They have no parallel function in seeing to it that a weapon state does not become a weapon state. Yet India has argued powerfully beginning in the 1950s and steadily since, that if special nuclear material civilian programs were to be safeguarded in India, they would have to be safeguarded also in the weapon states, such as the United States.

Safeguards in the weapon states would have a largely symbolic function, like the mimic grimaces of pain undertaken by fathers in the Trobriand Islands while their wives are experiencing the actual childbirth.* On the other hand, it would mean in practice a considerable allocation of IAEA's slender inspection resources to this symbolic act in the weapon states rather than to its actual business of seeing to it that non-weapon states do not get nuclear weapons.

The argument for equal safeguarding of weapon states also affected the U.S. consideration of the possibility of getting the spent fuel returned to the U.S., for example, by leasing it or buying it back.

---

*The Indians were even willing to acknowledge the symbolic character. They "observed, however, that they were primarily interested in the principle involved rather than in the opportunity to inspect U.S. facilities; and accordingly, they offered to provide the U.S. written assurances that no inspections would be performed by India." Report to the General Manager, AEC, by Director, Division of International Affairs, attachment to memo of July 8, 1963. Typescript in ERDA files.

Since the United States was a long way from having any use for large amounts of plutonium in its own civilian program, accepting Indian spent fuel might have meant inspection of its separation facilities for producing plutonium for weapons.* The Indians used the argument of equality to get one of the more tortuous provisions into the Agreement on Cooperation, the one on substitution for safeguarded material.

---

*See, for example, the memorandum to M. D. Bengelsdorf, Assistant Director for Program Development and Liaison, IA, dated April 12, 1963, from N. Stetson, Deputy Director Division of Production, of the AEC, on "Proposed Safeguard Arrangements with Government of India":

"The primary concern of the Division of Production would be with the processing of the spent fuel from the Tarapur reactor. There would be no major problems with international agency inspection of the Nuclear Fuel Services (NFS) plant since the proposed contract with NFS gives the Government the right to have foreign inspectors visit the plant. However, if the fuel must be reprocessed in one of the AEC chemical processing plants, problems of classification and security exist. Since the foreign inspectors may not have full run of the AEC production facility while their material is being processed, it may be necessary to rely upon reactor calculations or upon disolver sampling and analysis observation, if security permits, and *the set-aside equivalent quantity concept*.

"The paper is not clear with respect to our obligations to process fuels from the Tarapur reactor. I assume that the AEC is not obligated to process fuel or purchase plutonium. If this is the case, the AEC could refuse to accept fuel from Tarapur and thus avoid having the AEC facilities involved." (Italics added).

> Notwithstanding anything contained in this agreement the Government of India shall have the right, upon prior notice to the Government of the United States, to remove from the scope of this Agreement quantities of special nuclear material, provided it has, pursuant to mutually acceptable measurement arrangements, placed agreed equivalent quantities of the same type of special nuclear material under the scope of this Agreement. The Government of the United States of America shall have the same right with respect to special nuclear material produced at the Tarapur Atomic Power Station and acquired by it.*

In current terms, this would seem to indicate that the Indians, as they choose, can remove the fuel rods using uranium enriched by the United States, so long as they replace them somewhere along the line with exactly the same quantity. In other words, they can remove the rods before they have become very contaminated with the undesirable higher isotopes of plutonium, and then replace them with material from a third supplier, such as South Africa or France. They will then have from the Tarapur reactor something better than power reactor plutonium with which to fashion a nuclear explosive, and they will have it legally.

They can also use this clause of the Agreement to permit reprocessing of Tarapur spent fuel, which is safeguarded, in the same new Tarapur reprocessing plant which will also reprocess unsafeguarded fuel from CIRUS, Super-CIRUS, and the yet-to-function Madras power reactor. This eventuality had been assumed in both American and Indian discussions of Tarapur, but it arrives now to complicate the accountability of plutonium.

---

*Section 13 of the Trilateral Agreement between India, the United States, and the IAEA. "Application of Safeguards by the IAEA to the United States-India Cooperation Agreement." Signed January 27, 1971, Treaty Series 7049. U.S. Department of State.

TARAPUR

Preliminary negotiations for the Tarapur reactors began seriously with a visit from Dr. Bhabha to the United States in November 1959. The atmosphere of friendly collaboration and optimism for the future is reflected in the report of a return visit to India by an AEC team in March, 1960. Mr. Myron Kratzer, then Deputy Director for the Division of International Affairs, led the team, whose mission was to assess the technical feasibility and economic attractiveness of nuclear power in India in the near term. Representatives from the State Department, the AEC and its contractors accompanied Mr. Kratzer, and their objectives were spelled out in detail in a memorandum of January 25, 1960.

1. To review the Indian power requirements for the next ten year period and the key economic and technical assumptions underlying the Indian contention that a nuclear power program is justified at the present time.

2. To determine more precisely what the Indian plans are in terms of reactor locations, size, and cost.

3. To determine to what extent the Indians might wish and expect to participate in construction of the reactors and related facilities, and ultimately perform such supporting services and fuel element fabrication and fuel reprocessing services in India.

4. To assess the technical capability of the Indians to undertake a nuclear power program of modest size and to participate in such activities as design services, construction, fuel element fabrication, and fuel reprocessing. If fuel fabrication and reprocessing in India is contemplated either now or in the future, the financial impact of performing such services in India would be evaluated.*

It is interesting that the objectives focused only on technical and economic questions. There is no mention of proliferation. The desirability of reprocessing in India rather than outside is considered only in terms of saving foreign exchange. However, here the economic conclusion is rather cautious: India should initially reprocess in the U.S. or in the Eurochemic facility, and should not build its own facility "until the installed reactor capacity in India reaches about 1,000 MWe." The team recommends building at that time a plant that can reprocess natural as well as enriched uranium, on the assumption that India will look favorably on the purchase of a U.S. light water reactor. It assumes that India, like the U.S., will eventually recycle plutonium as fuel in its reactors.

Recognition of Canada's competitive natural uranium reactor is, of course, a strong underlying theme in the report. The AEC team naturally mentions the higher capital costs of the natural uranium reactor, but points out correctly that India's preference for natural uranium reactors is related to her desire to be independent of imported nuclear

---

*"Report by Team Member on a visit to India, February 29-March 18, 1960." Typescript in open ERDA files. Quotations which follow on AEC team are all from this source.

fuels. ". . . . Whether or not the use of natural uranium will avoid dependence on imported fuel depends upon the validity of the assumption that India can become self-sufficient in natural uranium pending the time that it can use its thorium resources. However, the Indians appear confident that natural uranium will be discovered and exploited in adequate quantities." The AEC team took a dim view, however, of India's ambitious 3-stage program culminating in the thorium breeder. "The original Indian conception to accumulate U-233 (thus enabling use of their thorium reserves) through preliminary stages of plutonium production in natural uranium, and U-233 production from plutonium [sic] in thermal converter reactors is unsound. Utilization of thorium by India will require an initial step utilizing enriched uranium, and/or the development of economic and effective breeders." (There seems to be a misprint in the trip report here. The second stage of the Indian plan involved producing U-233 from thorium in a converter reactor fuelled with plutonium.) The utilization of Indian thorium seems as far off in 1977 as it did in 1960. Utilizing "enriched uranium and/or the development of economic and effective breeders" make quite an "initial step," saved perhaps by the "or" in "and/or."

The AEC team made some very sobering observations about the limitations of India's heavy industry and its shortage of middle level personnel in both administrative and scientific fields. "Any nuclear power plant constructed in India in the near future would have to depend almost entirely on imported equipment and components." While India had the technical capability to operate such a plant safely and effectively, "under present conditions, design, procurement and errection of a nuclear plant should be the responsibility of a competent U.S. firm with undivided authority."

Nevertheless after an "extensive review of construction methods and costs in India," the team concluded that with savings of some equipment items purchased in Europe and lower local labor costs, the plant's construction would cost about 10% less than in the United States. "In the immediate future, enriched uranium nuclear power plants can be installed at a few selected points in India to yield power costs that are within the range of conventional power generation at the same sites." The report even goes so far as to suggest that the arrangement will be not only mutually beneficial, but of particular benefit to the United States.

The team's political observations were more acute than its economic analysis. The report indicates great awareness of Indian sensitivity about independence of foreign assistance, and notes that the problem of safeguards is likely to be a central one in the negotiations.

> A special aspect of the political questions affecting nuclear power development is India's attitude toward safeguards. At present, India's professed position is that it has no objection 'in principle' to safeguards on enriched uranium, but will not accept safeguards on natural uranium which it believes to be available in abundance from many sources without safeguards. However, India has made no effort to define the form of safeguards for enriched uranium which it might find acceptable. It is clear that, in reality, India wishes to avoid safeguards in all forms and to the maximum extent feasible, and will accept them as a matter of expediency only when it derives some advantage

> from doing so. This is illustrated by India's acceptance of safeguards with respect to heavy water when this was made available to them on a lease basis.

Mr. Kratzer's doubts on this score were fully justified. It took until August 8, 1963 for the United States and India to come to terms on a Bilateral Agreement that was especially designed for India. The loan agreement was signed on December 7, 1963 and on May 8, 1964 General Electric and its Indian subsidiary signed a contract for the Tarapur Power Project. The U.S. press release billed it as "the largest commercial contract ever undertaken in the General Electric Company's history."

The Tarapur loan deserves a place in history as a pr~~emium~~ime example of a soft loan and actually a very large gift: 3/4 of one percent interest, a 40-year loan with a ten year grace period. (The market for such loans is hardly a borrower's market.) The terms of the loan caused some hesitation in Congress, in addition to the fact that some of its members had had a bit of experience with India's former responses to American generosity.

During the hearings in 1964 on U.S. arrangements for financing the Tarapur reactor, Senator Aiken, for example, recalled,

> I wouldn't be so skeptical if I didn't have something to do with the wheat deal for India. When they were having famine conditions we shipped them wheat and they wouldn't let us land the wheat we were giving them until we paid customs duties on it.*

---

*International Agreements for Cooperation. Hearings before the Subcommittee on Agreements forCooperation of the JCAE, Sept. 5, 1963, April 22 and June 30, 1964. USGPO, 1965, p.88.

And Representative Hosmer had had a similar problem:

> Do you recall when we were having trouble with the Chinese up on the border a couple of years ago and the Indian Government Collector of Customs were stopping the boxes at the port of embarkation, opening everything up and putting a customs stamp on it, after a leisurely period of time before the rifles were sent up to the men in the front line. This is the kind of thing that is bothersome to the country boys like me.*

These remarks were made in connection with the fact that part of the cost of $118 million for the Tarapur borne by the United States was in customs duties of $5,610,000 on the goods being sent in from the United States.

Chairman Pastore also mentioned an article in the press where "Gandhi's daughter" (actually Nehru's daughter) was taking America to task for the U.S. attitude to the Kashmir dispute.

> The American taxpayer sometimes is willing to do these things in order to stabilize these governments or so that they will be our friends. . . . But what difference does it make? We are still spending money to be rebuked, and that is a hard thing to take. I think that is what is troubling us here.**

Representative Bates chimed in:

> And besides the Joint Committee was not permitted to overfly India.***

---

* p.86
** p.82
***<u>Ibid</u>.

Chairman Pastore then summed up,

> If we are losing good will, what are we buying here? This is not a business transaction in the strict sense of American business understanding. There is no question about it at all . . . we are subsidizing the deal between GE and the Indian Government and the American taxpayer is making a grant.* [As it turned out, GE was making a grant also.]

The consensus of Congressional opinion was that the Indians drove a hard bargain and were quite capable of looking after their own interests. The State Department representative, Mr. Vagliano, was asked for his point of view and he protested mildly that we were not in this aid program "necessarily to be liked by the Indians." That would not be a "particularly good investment. But I think that the hope, possibly the cautious expectation ~~is~~ that over a period of x years, that country will be in a state where it will be strong both economically and able to take care of itself, and that it will be on the side of the West. At that point, we will be in a situation where it will be a good market for us, too."**

Congressional opposition was overcome by the fact that the economics of the Tarapur Project had been under intensive study for some time. AID had financed a study by the private firm of Burns and Roe, as well as a five year study by the Government of India under the leadership of Walker Cisler of Detroit Edison, and Professor E.A. Robinson of Cambridge. Unfortunately the economic analysis done by Burns and Roe was faulty and biased toward the nuclear alternative. It had the usual predisposition to use low interest rates so that the top of its range of interest rates

---

* _Ibid_.
**_Ibid_., p. 83.

was the bottom of the range of interest rates indicated as more reasonable by I.M.D. Little. It left out the cost of all the fuel reloads in the case of the nuclear alternative. It dealt with the alternative of coal, but did not recognize that some of the coal was available, except for the expense of transportation, at essentially zero cost (as a result of what economists call externalities--in this case benefits from other industrial operations). As for transportation costs, Burns and Roe did not adequately consider the possibility of developing cheaper methods of transporting coal. In the Bombay region, which has a seaport, improved water transport might have yielded particularly low costs for bulk shipment of coal. And improved transport would have generally beneficial effects on the economy. Burns and Roe recommended the project, with only minor qualifications, and AID followed suit.*

By contrast the Energy Survey of India Committee, which had a galaxy of American, British and Indian advisors, including Homi Bhabha himself, recognized the modest role that nuclear energy would probably play in India's plans for the next 20 years.

> If the construction operating costs of nuclear energy can in practice be at the levels we have set out . . ., nuclear energy is likely to have an increasingly important part to play. But while its contribution to the problems of the next century may be great, its contribution to the problems of the next twenty years, however, represents a small fraction of India's total energy requirements.**

---

* Details are provided especially in Section V, "Economic Analysis of the Project," India - Tarapur Nuclear Power Project, AID-DLC/P-170.

**Report of the Energy Survey of India Committee, New Delhi, the Government of India, 1965, p.6.

The Committee concluded that the cheapest method for generating electric power in India was coal and that coal was cheaper than nuclear electric power on all but the most optimistic assumptions for the nuclear alternative:

> A low coal-cost thermal station such as can be constructed to burn by-product or waste coals at the coal-field, if operated at a plant factor of 60% or better is probably the cheapest method of generation of all.*

The fact that Walker Cisler, a prominent proponent of the use of nuclear energy for electric power was a leading figure in the inquiry lends a great deal of weight to that opinion. But as William Hoehn points out, even though this survey was reportedly going on during the time of the Burns and Roe investigation, there seems to have been no communication between the two groups, in spite of the fact that both were financed by AID.**

The actual performance of India's nuclear plants confirms all the skepticism exhibited by Little and Hoehn. The capacity factors are a good example, but also the length of time for construction, and the miserable maintenance record. The notion that India could lead the Third World in growth through nuclear power is denied by the figures. The per capita national income in real terms had grown by only 11% from 1960-61 to 1974-74. The annual growth rate during the Third Plan had been only

---

* Ibid., p.132,

**See William E. Hoehn's analysis in "The Economics of Nuclear Reactors for Power and Desalting," RM-5227-1-PR/ISA, November, 1967, Chapter IX, "Nuclear Power in Less Developed Countries," p. 144 ff. The Rand Corporation, Santa Monica, California.

0.3% and in the Fourth Plan 0.5%.* These figures can hardly be a tribute to the allocation of effort in aid to nuclear energy rather than to other more productive fields.

It is then with some fatigue that we listen to Parliamentarian Subramanian Swamy of the Jan Sangh party complaining that the Indian government is still taking too much into account the costs of economic development, when it considers nuclear energy, both civilian and military. After all, he points out, the government did not let economic considerations influence it when it was putting in its steel complex at Bokhara.** That is quite true, and as we now know, the Indian public sector plant has been a disaster from the point of view of India's economic development. Our former ambassador to India, Daniel P. Moynihan, has summed it up:

> In the year of its independence, 1947, India produced 1.2 million tons of steel and Japan only 900,000 tons. A quarter century later, in 1972, India produced 6.8 million tons and Japan 106.8 . . . The break in Indian growth came precisely in 1962 when the United States, which had been about to finance its largest aid project ever, a steel complex at Bokhara in Eastern India, insisted that it be managed privately. India insisted on a public-sector plant, for which read a plant that would do what the Prime Minister of India wanted done. In the manner of the Aswan Dam (and with as much political impact), the Russians stepped in to finance the public-sector plant. By 1974 this plant had yet to produce sheet steel. For the period 1962-72 Indian steel production grew by a bare 1.8 percent, while Japanese grew 13.4 percent.***

---

* Economic Survey, 1974-75, Table 1, "Gross National Product and Net National Product," New Delhi, The Government of India, 1974-75. p. 59.

** "A Weapons Strategy for a Nuclear India." India Quarterly, October-December 1974.

***Daniel F. Moynihan, "In Opposition," Commentary, March 1975, p. 40.

In the case of steel we were clear that India's proposal was not going to be the best way for India to catch up with the industrial West. We also regarded its political value as dubious, although Indian motivation for a public sector plant was primarily political. In the case of our economic subsidies to Tarapur, we were less discriminating.

FROM CIVILIAN POWER TO MILITARY POWER

There is substantial evidence that the initial Indian decision to separate and accumulate plutonium was made for purely civilian, though somewhat vaguely defined purposes. However, several events intervened between the beginning of a nuclear explosive program in the mid-sixties and the formulation nearly a decade earlier of a long-term civilian power program, which included the Phoenix plant for separating plutonium for ultimate use in a breeder reactor. These events made highly probable the transition from nuclear electric power to a nuclear explosive program with military applications more immediate and persuasive than any civilian application in a breeder or near-breeder reactor.

The first of these events was the Sino-Indian war in 1962, and the unexpected humiliation of the Indian armed forces. Second and perhaps most influential was the remarkably successful conclusion of a Chinese nuclear weapons production program, issuing in a series of tests beginning in October 1964 with a uranium fission bomb, then the testing in May 1966 of a fusion device, and culminating in a nuclear armed missile test in October of that year. Third was the experience of armed conflict with Pakistan over Kashmir in 1965, in which the Chinese issued statements of support for Pakistan and cautionary threats against India for what it described as "criminal agression", and finally an ultimatum that India pull back from Chinese territory bordering Sikkim or face "grave consequences."* During the war the United States and the Soviet Union sought to restrain China with public and private messages; and the United States cut off aid to

---

*William J. Barnds, <u>India, Pakistan and the Great Powers</u>, New York, Praeger, 1972, p.206.

both India and Pakistan. However after the war had ended India grew increasingly resentful that the United States did not immediately re-institute military aid for India because of the threat it faced from China.

In 1962 increasing tension along the Sino-Indian northern border had finally broken into severe fighting on October 20. It continued to November 20, when the army of the People's Republic of China inflicted a humiliating defeat on the Indian army. With this shock the possibility of a military nuclear option became a subject for private discussion and speculation in the Foreign Ministry and the Indian AEC. The issue burst into the open on October 16, 1964, when the People's Republic of China exploded its first atomic device in the deserts of Western Sinkiang. Alarms were sounded around the world, but India felt herself particularly threatened. The pro-bomb advocates in the press became more vociferous as did the spokesmen for the Jan Sangh party. There were numerous counter-statements by scientists and statesmen in the dominant Congress Party on how strong and peaceful and moral India was, though there were some cracks even in this official armor, including a suggestion that India's moral position might be improved in forwarding disarmament, if she could speak as an equal to the great powers, i.e., as a member of the nuclear club. Prime Minister Shastri himself raised these questions before the Lok Sabha on November 24, 1964: "What we will gain by manufacturing the atomic bomb, how far it would be able to increase our strength, and to what extent we may be able to gain parity with the nuclear powers, and what burden it will impose on the country? And whether, at the same time, would we be able to work more for peace or to raise a stronger voice against nuclear warfare and nuclear weapons, as India has been doing until now."* As another high Indian official said at the time, "It is only when we have the bomb, that we can renounce it convincingly, in the manner of Ashoka, and make a dramatic impact on the world in order to reverse the mad career of mankind to universal destruction."**

The government of India has always insisted that its atomic energy program would be devoted only to peaceful uses, and Dr. Bhabha had set forth that position in numerous speeches during his last years. But the first Chinese explosion caused a significant change in his public pronouncements. Eight days after the explosion on October 24, 1964, in celebration of United Nations Day, he spoke in glowing and urgent terms on nuclear disarmament. This has been a theme song of many non-weapon states who feel themselves "outcasts" from the so-called nuclear club, a caste status to which India, in particular, was sensitive. If they are deprived of nuclear weapons, so the argument goes, then the great powers should not have them, and should show their good faith by renouncing them. Indeed, it is hypocritical, they say, to speak of nuclear disarmament other than in terms of general and complete disarmament.

---

* Reprinted in Survival, (March-April 1965), Volume 7, Number 2, p. 59.

**Interview, April 1966, name withheld on request. Since the explosion, K. Subrahmanyam, Director of India's Institute for Defense Studies and Analyses, has argued, ". . . one may legitimately regard the Indian test explosion as a contribution to the increased influence of India in international disarmament negotiations." ("The Indian Nuclear Test in a Global Perspective," New Delhi, India International Centre, 1974, p. 7.

Dr. Bhabha apparently departed from this theme of disarmament in his speech on October 24 when he pointed to the savings in conventional arms permitted by the acquisition of nuclear weapons. But the sense of his talk, suggesting that nuclear armament might permit conventional disarmament, provided one congenial rationalization for undertaking a military nuclear program. Dr. Bhabha said:

> A minimum supply of nuclear weapons coupled with an adequate delivery system confers on a State the capacity to destroy more or less totally the important cities and industrial centres in another State.*

Not only that. It seems "atomic weapons give the State possessing them in adequate numbers a deterrent power against attack from a much stronger State." He then went on to say (quoting from a future Plowshare price list presented by two Livermore scientists) how little an atomic explosive costs--"a 10 kiloton explosive at $350,000, a two megaton explosive at $600,000." This proved, he thought, ". . . that atomic explosives are some 20 times cheaper and thermonuclear explosives 500 times cheaper than conventional explosives." A bargain hard to turn down.**

Bhabha's dream here is no longer of electricity throughout the villages of India, but one of absolute deterrence. Here the fact that

---

* Bhabha, "Nuclear Disarmament," Nuclear India, radio address published by the Indian Department of Atomic Energy, Volume 3, November 1964.

**Gerald Johnson and his co-author Higgins, in citing possible prices for two U.S. plowshare devices, presumably were pricing them at the extra costs they would entail for the United States to produce, starting from the U.S. nuclear weapons program at the time, with many billions of dollars already invested. Needless to say, the cost to India to make a few fission and fusion devices of this sort, starting from where the Indian program was at the time, would have been of another order of magnitude.

India is large, though poor, holds a promise. ". . . if countries were free for a decade or more, as at present, to develop nuclear weapons on their own," then "at least a few countries, and especially the very large ones, could get into a position of having a nuclear deterrent force against any other." (That of course has been the will o' the wisp of Minimum Deterrence even for small countries, to say nothing of large ones like India.) He concludes, somehow, that from this position follows the need for "substantial progress toward general disarmament" as soon as possible. The Chinese explosion has made clear that "there is no time to be lost."

Indian officials continued to use the rhetoric of non-alignment and universal disarmament while in fact India was aligning herself against China and actively seeking some sort of guarantee against a Chinese attack. The desire to preserve her reputation for non-alignment affected the character of the guarantee she sought. In the mid and late sixties she was looking for a guarantee from both the United States and the Soviet Union, and privately admitting that mutual disarmament by these two powers would do nothing to protect her against China. Off the record interviews in 1966 and 1977 also made plain that Indian officials would put no trust in any promise by China to disarm totally. No such promises to disarm would substitute for an Indian nuclear weapons program since, they claimed, the non-existence of Chinese bombs in the vastness of China's territory could not be verified.*

Bhabha, however, was not alone in his feeling of urgency, and during 1965 that feeling increased as the skirmishes with Pakistan developed into war. Eight-six members of the Indian Parliament appealed to Prime Minister Shastri in September, 1965 to undertake a nuclear weapons program. As one historian, H. R. Gupta summed it up, "After the Pakistani war, almost the entire nation wanted India to go nuclear."** In his reply

---

* See Addendum G, Interview, among others, with C. F. Jha by Albert Wohlstetter April 19, 1966, New Delhi. See also the lengthy interview by Arthur J. Dommen with Sisir Gupta of the World Affairs Council in New Delhi, in connection with the organized opposition of some Indian intellectuals to the NPT:

"'We are in the paradoxical position of wanting the United States and the Soviet Union to announce they have agreed on the need to halt proliferation, and at the same time of telling them that they will not be able to dictate our security policy'. ¶ Gupta says that arguing, as the Indian delegation at Geneva has done in the past, that a nonproliferation treaty is unfair as long as it does not compel the nuclear "haves" to make a sacrifice also in the form of reducing their own stocks of weapons is futile, since any such reduction by the two superpowers, the United States and the Soviet Union, would be entirely symbolic, and *no one expects China to be governed by any disarmament resolutions passed at the Geneva conference anyway*. ¶ *Moreover, narrowing the gap between the superpowers and China by forcing the former to take steps to reduce their capability is not in India's interest*. ¶ Instead we should try to get China priced out of the market, Gupta says, by nullifying the credibility of China's nuclear potential. ¶ Gupta agrees that the threat from China's growing nuclear capability is entirely political. He believes that of all the five nuclear "haves" China is the most likely to make use of its nuclear weaponry to blackmail its neighbors. ¶ 'We must go on emphasizing the danger of proliferation and say it is not a good thing,' Gupta says. 'But we should not close the debate.' ¶ Gupta, 38, who studied at the University of Pennsylvania and Massachusetts Institute of Technology, was interviewed in his office at the Indian Council of World Affairs here." "Group Opposes India's Signing Nuclear Pact", *Los Angeles Times*, March 6, 1967, (Italics added); and interview with Dr. Lee Rose, University of California, Berkeley, March 3, 1977, who was in India in 1965.

**H.R. Gupta, *India-Pakistan War 1965*, Hariyana Prakashan, Delhi, 1968, p.112.

to the Parliament, Shastri declared, "it is not our policy at present to go in for atomic weapons," and later on October 19th of that year he said "It would not be a bad thing to forget the atom bomb altogether."*

It was in the midst of an intense national debate for or against the nuclear military option that the Phoenix reprocessing plant was formally inaugurated on January 22, 1966. The publicity went far beyond anything that had occurred at the inauguration of the CIRUS. Prime Minister Shastri gave the main address to an audience of 5,000 which included a score of Indian government officials and 40 visiting dignitaries. Among the visitors were noted Mr. J.L. Gray, president of the Canadian AEC, Mr. John G. Palfrey of the U.S. AEC and Mr. J.M. Hill of the British AEC. AEC representatives were also present from Denmark, Norway, Sweden, Belgium, Switzerland, Japan, Australia, Afghanistan, and Pakistan, as well as Director General Eklund of the IAEA and his deputy Mr. Goswami. The Times of India headlined the visitors' approval: "India's Stand Hailed by Visiting Experts: Atomic Energy Solely for Peaceful Purposes."** This had been the theme of the Prime Minister's address the day before, describing the plant as "a bridge between atomic power stations based on natural uranium and future stations with breeder reactors based on the thorium-uranium-233 cycle",*** the key to raising INdia's standard of living as well as her independence in energy. Dr. Bhabha also spoke, and emphasized the same themes. He noted further

---

* Ibid. quoted p.112.

** The Times of India, Jan. 24, 1965. I am indebted to Richard Speier for this reference. His doctorate, United States Strategies against the Proliferation of Mass Destruction Weapons (Massachusetts Institute of Technology, 1968), is one of the earliest public discussions of the dangers of plutonium reprocessing in India.

***The Times of India, Jan. 23, 1965.

however - in an aside perhaps intended for the absent Chinese - that "the capacity of the present plutonium plant had proved to be many times its planned capacity and the progress in atomic power generation had been such that this plant was sufficient to treat the used fuel elements from all the natural uranium atomic power stations which would be in operation by the end of the Fourth Plan /in 1973/"*

Six months later, using another method to broadcast the double-edged character of his nuclear program, Dr. Bhabha conducted a public relations tour of the Phoenix plant for five correspondents (four British and one American). The enthusiastic report of one of them, Victor K. McElheny, implies that the plant is functioning successfully. It "...has not yet separated the 10 kilograms of plutonium generally said to be desirable for a single atomic bomb, but it soon will."** Dr. Bhabha's knowledge of the bomb potential of the CIRUS plutonium was not necessarily shared by his compatriots in the Indian government, for in the midst of this publicity, they continued to deny plans by India to become a military nuclear power and reemphasized the need for plutonium fuel in the breeder.

Indian cries of alarm and threats to go nuclear aroused some uneasiness in the Canadian press, and finally reached the floor of the House of Commons. On November 2, MP Andrew Brewin rose to question the Secretary of State forExternal Affairs, Paul Martin, as to whether there was anything to the press reports about "the possibility of India using the reactor which was contributed by Canada under the Colombo plan for the production of a nuclear bomb?"

---

* Ibid.

**McElheny, V.K., "Electric Power Remains Emphasis of India's Nuclear Energy Program," Science, Vol. 149, July 16, 1965, p.284.

Note that the questioner identified the product of the CIRUS reactor as material for a bomb, that is, as an explicitly military weapon. That identification made it easy for the Secretary not to face the more important issue as to whether a nuclear explosive, however labeled, was a possible product. He replied:

> . . . As regards the policy of the Indian government in this matter, I think the record is clear. Prior to the Chinese explosion, and subsequently in the face of that event, the prime minister of India stated that India is maintaining its policy of not manufacturing atomic weapons. I regard this declaration as a positive contribution to world peace.
>
> Insofar as the Canada-India reactor is concerned, under an agreement concluded with India in April, 1956 and tabled in this house on May 9, 1956, the government of India gave an unconditional undertaking to use it for peaceful purposes. The relevant article of the agreement reads as follows:
>
> "The government of India will ensure that the reactor and any products resulting from its use will be employed for peaceful purposes only."*

If such declarations are positive contributions to world peace, then peace may be advanced steadily while an approach to making nuclear explosives proceeds apace.

But Mr. Brewin at any rate was reassured, and the climate of opinion at the time made it unlikely that the question would be raised or pursued in any very stark form. (Was India likely to do what she later did, that is, make a nuclear explosive plainly capable, with minor modifications, of military use, however doubtful its application to digging canals?) India, in most minds, we must remember, was not yet the country of Indira, but rather of Mahatma Gandhi, firmly attached to peace, if not to non-violence. And while doubts may have surfaced by 1964, it is also important to remember the atmosphere that prevailed in 1956 when the Canadian Indian agreement was signed. According to one Canadian report,

---

*Canada, House of Commons Debates, 26th Parliament, Second Session, Volume IX, (Ottawa: Queen's Printer, 1964). p.2587

> The announcement was warmly received. We still carried vivid memories of the atomic explosions over Nagasaki and Hiroshima 11 years earlier; we knew, the world knew, that survival depended on deflecting this fearsome power from war to peace. What better place to share our atomic technology than in India, an impoverished nation whose dedication to peace was manifest, a nation that could be trusted to use this new resource for much-needed nuclear power, not for bombs."*

And since only Canada was exploring the deuterium-uranium or heavy water approach, the "Indian agreement was a double triumph: it not only marked us as a generous and responsive people, it provided a showcase for our technical expertise, a sample for our wares. Nobody, at first, questioned the CIR deal."**And in 1964 no one seriously wanted to question it. Except Pakistan, whose government sent a stiffly worded diplomatic note to the Government of Canada, and who received the same sort of assurances.

Nevertheless in India, Bhabha was now intent on developing nuclear explosives. Sir John Cockcroft had noticed that Bhabha in his official pronouncements always followed the policy of his government. But "in discussions at small closed meetings he appeared to be in favor of making bombs for a Plowshare programme."*** < change to PNE in general place

The indications are that Bhabha's view prevailed throughout his own Department of Atomic Energy, and (especially after the Sino Indian war of 1962 and the Chinese nuclear test) also in the foreign policy establishment and in a faction of the Congress Party. But the momentum

---

* Walter Stewart, "How We Learned to Stop Worrying and Sell the Bomb," McLean's National Magazine, November 1974. Reprinted as Appendix 8 to U.S. Foreign Policy and the Export of Nuclear Technology to the Middle East. Hearings before the House Committee on Foreign Affairs, 1974, op. cit.

** Ibid.

***Sir John Cockcroft, op. cit., p. 421.

of his contribution to the drive toward developing nuclear explosives was lost with his sudden death in an air crash in 1966.

However a new incentive for India to undertake a nuclear weapons program had come as a byproduct of India's brief war with Pakistan in 1965. Fighting broke out between the two countries in April and then again in August, and in September the United States finally cut off military aid to both Pakistan and India. In India this loss occasioned less hard feeling at the time than might have been expected. American aid had been quietly offered during the war and remained generous after the Indian defeat in 1962. The United States had worked with Great Britain to set up an air defense warning system, which was not yet complete at the time of the troubles in Kutch and Kashmir, but aid to Pakistan had been much less. India had been complaining since April about Ayub's use of American supplied arms against India, and the cutoff in effect benefited India, at least so far as its military position against Pakistan was concerned. However, after the war had ended, and a "no war" agreement had been signed by both parties early in 1966, with the Soviet Union as mediator, the U.S. failure to reinstate military aid caused a growing resentment.*

The resentment had to do in particular with the fact that India had given great importance to the air warning system, in particular in relation to China. In the Sino-Indian war in 1962 India had felt its cities would be totally vulnerable to a possible Chinese air attack, mainly because the cities had no substantial aircraft warning system and therefore no possibility of

---

* See the account in William J. Barnds, India, Pakistan, and the Great Powers, op.cit., Part III, "Confrontations and Their Consequences", pp.165-237., and Chester Bowles, "Candid Comments on Indo-American Relations", 1965 in A View From New Delhi, Selected Speeches and Writings, 1963-1969, Allied Publishers, Bombay, 1969., pp. 174-181.

For more detail, see Hari Ram Gupta, India-Pakistan War 1965, Volume II, Hariyana Prakashan, Delhi 1968, especially Chapter 15 (3), "The Only Solution".

passive defense measures of evacuation or active defense measures of interception. This was one of the reasons that the Indians themselves dared not risk the use of their own air force in the course of the war. A paralysing concern about the vulnerability of their major cities to conventional attack is a factor in the deliberations of some other potential nuclear powers, namely South Korea and Israel, and sometimes it has suggested to them the need for a desperate last resort capability for nuclear retaliation against adversary cities. In the case of India, however, the ranges to important Chinese cities are extremely extended.

The fact that the Indians may have been in part influenced in their decision to undertake a nuclear explosive program by a cutoff in conventional military assistance provides some evidence that policy on military sales or military aid needs to be considered carefully as part of any anti-proliferation policy. Some military sales might complement and encourage the acquisition of nuclear weapons; on the other hand some might actually substitute for and reduce the incentives for nuclear force. If the latter kind of military arms transfer is cut off, it may be one of several precipitating factors in a decision to undertake a nuclear weapons program.

Indian economic planners had tried to slow the nuclear program during Bhabha's lifetime. They were concerned that large expenditures on civilian nuclear energy (not to say military nuclear energy) would interfere with the overall development of the Indian economy. They were joined by the military, who in turn feared a reduction in their budget for conventional forces. Both the economists and the military were a good deal more realistic than the physicists about the costs, first of an explosive, and then of an adequate delivery system. The economic planners at that time, according to grumblings in the Ministry of External Affairs, had too large a role in government policy making. The Ministry view is reflected in a public statement by Sisir Gupta, then Director of the Council on World Affairs of New Delhi:

> The lop-sided emphasis on the cost aspects of the atom bomb in the current debate over the advisability of reviewing India's declared policy is a measure of the disproportionate importance given in India to the economists' view in the determination of all major State policies.*

The military opposition was gradually eroded in 1966 and 1967 by worry about withdrawal of American arms aid after the 1965 war with Pakistan, and by enlarged budgets granted by the Government of India for conventional arms. Today, India has the fourth largest conventional force in the world. And for the kind of nuclear spread we focus on in this ~~report~~ study, sophisticated delivery systems may not be important.

*Sisir Gupta, "Break with the Past," in a symposium entitled "The Bomb", Seminar, New Delhi, January 1966, p.28.

Indian economic planners in the sixties also lost out gradually to other government factions. In 1970, when the Indian space program was incorporated into the AEC, one commentator noted cynically that the AEC blueprint for a substantial acceleration of both the space and nuclear programs was trying to ". . . cash in on the country's growing concern about China's capabilities. The AEC is obviously hoping that the persnickety economic planners in New Delhi will not now look as closely into costs and benefits as they did when they decided to allow only Rs (Rupees) 150 million for new nuclear power projects during the fourth plan running from 1969 to 1973."* (The most frequently cited price tag for the ambitious ten year plan, according to Wayne Wilcox in 1971, was $1.6 billion.** He foresaw an Indian missile-thermonuclear force coming into being some time in the 1980s.)

Indian anxiety about the People's Republic of China mounted with the second and third Chinese tests and grew to a fever pitch, when the the first nuclear armed missile was launched on October 27, 1966. Then the Indian press reacted angrily, recalling earlier American assurances that India had nothing to fear because China lacked a delivery capability. America, it asserted, was under-reacting for fear that India might "crash into the nuclear club."*** Cables from the American Embassy

---

* Dilip Mukerjee, "Itching for the Bomb," Far Eastern Economic Review, (July 9, 1970).

**Wayne Wilcox, "Nuclear Weapon Options and the Strategic Environment in South Asia," California Seminar on Arms Control and Foreign Policy, June 1971.

***Indian Express, editorial of Oct. 29, 1966, Cf. also The Patriot editorial of the same date.

referred to the growing pressure from the pro-nuclear faction in India on the Indian Government to enter the military nuclear field.* The United States government itself had in fact been exhibiting a good deal of concern, beginning with the first Chinese test, and had considered a large number of alternatives for dealing with the People's Republic. Witness the now public set of documents known as the Gilpatric Report.** Any country seriously interested in non-proliferation is not likely to welcome a new member to the nuclear club.

---

* See, for example, New Delhi cable 6547 and Bombay 785, both of November 2, 1966. (unclassified, released under the Freedom of Information Act.) Indian and American press reports support this fact of pressure also. (Clippings available on request). On June 30, 1966 at the Rand Corporation in Santa Monica, California, Roberta Wohlstetter interviewed Dr. S. Bhagavantam, Science Advisor to the Defense Minister, and Director General of Defense Research and Development for the Government of India. He "felt very strongly that the Prime Minister needed objective advice for the pending decision on whether or not India should acquire nuclear weapons. As he described the situation, pressure is currently being brought to bear by the public, by members of the Parliament and by various government agencies to go nuclear, but the pressure is uninformed and emotional. Newspapers play up the Chinese threat; members of Parliament aim at getting votes; the Ministry personnel are largely ignorant." excerpt, page 30 of The State of Strategic Studies: Japan, India, Israel, July 1966. Report to the Carnegie Endowment for International Peace, July 1966.

**Available at the John F. Kennedy Library, Massachusetts. A secret State Department study begun in the fall of 1964, on how to deal with China and further proliferation, recently declassified. A memorandum of November 26, 1964, on "Problem Areas and Suggested Assignments" under the heading, "Policies toward Existing Nuclear Countries" mentions four courses of action with respect to the People's Republic of China.

"g) possible international political foundations (Gen. Assembly action, etc.) for action to frustrate further Chinese tests.
h) the military possibilities of eliminating the Chinese nuclear capability.
i) the possibility of "punishing" China for a subsequent test.
j) policies designed to turn China into a friend."

("Presidential Task Force on Nuclear Proliferation", Major Documents, Table 2, Memoranda, Box 10, Roswell Gilpatric Papers, John F. Kennedy Library.)

In India a typical and important pro-bomb advocate at that time was Dr. Gopal, son of President Radhakrishnan and head of the "Historical Division" of the Ministry of External Affairs. (The Historical Division had been misleadingly titled in the British manner. It corresponded to our Policy Planning staff in the State Department.) Dr. Gopal wanted a "plowshare" type of explosion soon, as a demonstration for prestige purposes. He claimed that his view represented that of the overwhelming majority of members in the Ministry. Other interviews* at the time seemed to confirm his claim. It was visible also in the World Affairs council, the foreign policy establishment outside the government. Dr. Gopal pointed out that an underground explosion of this sort would not be inconsistent with the Limited Nuclear Test Ban Treaty. When asked if India would use plutonium derived from the operation of the Canadian-India CIRUS reactor, Dr. Gopal replied, "Yes." Would this be consistent with the "peaceful uses" agreement covering the CIRUS? Again Dr. Gopal answered, "Yes." Would that be agreeable to the Canadians? "That," he felt, "would certainly be an acceptable interpretation of the arrangement."** "Of course," he added, "there

---

* See Addendum G for list of interviews by Albert and Roberta Wohlstetter in 1966 and 1967.

**Interview with Dr. Gopal by Albert Wohlstetter, April 18, 1966.

is always some possibility of disagreement on meaning." Was he aware that Plowshare devices to move earth would be low fission fraction, and quite different from what he had in mind? He answered, "I should think that if any debris leaked out, the dirtier it was, the clearer the Indian message would be."*

Dr. Gopal also claimed that Prime Minister Shastri had in late 1964 authorized Dr. Bhabha to develop the necessary technology for an Indian nuclear device, in order that this could be done expeditiously if and when a favorable political decision were made to go ahead. Shastri's order was an answer to Chinese hostility and was given added impetus by the partial withdrawal of American military aid in 1965. Gopal claimed that Bhabha had reduced the required 18 months lead time to six months. This probably meant that Bhabha had government approval for work on bomb design and its nonnuclear components.

Dr. Gopal's views about peaceful explosives and those of the other strong advocates in the Ministry of External Affairs for Indian nuclear weapons were reported to the American Embassy, with the suggestion that the report be forwarded to the Canadians for clarification and action. The Embassy doubted that Dr. Gopal was a spokesman for the government of India in nuclear matters, but believed that nevertheless the matter bore watching. Of more interest to the Embassy was the report that the Indians might use plutonium from the Canadian reactor for their first nuclear explosive. The Embassy had been informed by an officer of the Canadian High Commission that in view of the agreements covering the CIRUS, Tarapur, and the First Rajasthan Reactor, the Indians

*Ibid.

unanimously abjured the thought of India's breaking international agreements to obtain the plutonium. On the other hand, they did plan to use plutonium from the Indian-made Madras reactor. When informed that the Madras reactor would not be operational for many years, these otherwise well-informed persons appeared to be genuinely surprised.*

Perhaps the most interesting American reaction was the apparent awkwardness felt about trying to inform our Canadian friends that they might have some misunderstanding with the Indians.* The High Commission had previously informed the Embassy that Canadian officials had had no occasion to discuss with the government of India the particular question of whether or not an Indian peaceful nuclear explosion utilizing plutonium from the CIRUS reactor would be a violation of the peaceful uses agreement, because the Indians had never raised this subject with the Canadian government. Under the circumstances therefore it was conceivable that Dr. Gopal and other members of the Indian government might be interpreting Canadian silence on this issue as tacit acquiescence. But the Canadians plainly regarded this misinterpretation as rather farfetched. Still the possibility raised a very delicate question about how to suggest to the Canadians that they might indicate to the Indians on their own initiative that the government of Canada would consider any Indian initiative to use plutonium from the CIRUS for a "peaceful nuclear explosive" as being inconsistent with the Canadian Indian Agreement. The Embassy finally decided to suggest that perhaps the best method would be to raise the subject in a general way with the Canadian government to see if the Canadians might believe there was a reasonable chance

---

*See Addendum G

that the government of India might be misinterpreting Canadian silence on this subject.* All very discreet.

After a considerable amount of delicate pulling and gingerly hauling, and some four months later, apparently something was done. Spurred perhaps by the Chinese missile test, the U.S. did approach the Canadians and finally it came to the point that on August 24, 1966, General E.L.M. Burns rose on the floor of the Palais des Nations, Geneva, to give a speech on proliferation and the Non-Proliferation Treaty (NPT) to the Eighteen Nation Disarmament Committee. His reference to nuclear explosives consisted of the following statement, buried in a nine page long speech, at a meeting dominated by some polemic of the representative from Poland against U.S. actions in Vietnam.

> In our view the development by a non-nuclear weapon state of the capacity to conduct a nuclear explosion even though it is designed for peaceful purposes would in effect constitute proliferation, and proliferation is a development to which the Canadian government has repeatedly declared its opposition.**

General Burns's mention of the Canadian view of peaceful nuclear explosives was not only made in passing, but was quite general. He did not refer to Indian or Canadian Bilateral Agreements with any country. He was simply making a comment on a future provision of the Non-Proliferation Treaty and he tied it to a similar abstract statement by Adrian Fisher of the U.S. delegation which also referred--not to any U.S. Bilateral Agreement--but to the NPT.

---

* Albert Wohlstetter reported the substance of his interviews to the Embassy in New Delhi several times in April 1966.

**Typescript sent to the author by General Burns, ENDC/PV.285.

The Indians of course were not likely to sign and ratify the NPT, and the careful, continuing neglect of PNEs in the bilateral arrangements was only one more inducement for the Indians to resist membership in the NPT, which was about to ban PNEs for non-weapon states.

The message to the Indians, if it got through at all, had an operational content opposed to its apparent meaning. The operational content was: If you want to explode a PNE, don't join the NPT. But the message in any case was buried in a great deal of extraneous sentiment.

Did the Indians hear the signal at all? It is not clear. At any rate they were not heard from. Canada apparently took some comfort in Indian silence in response to this and later communications. The path of development of this exchange of non-communications described a nice parabola, beginning in 1966 with the High Commissioner's doubt that the Indians could possibly take Canada's silence as acquiescence and ending in a terminal point in the early 1970s with the Canadians taking the Indian silence as acquiescence.

For anyone listening, there were many other signals, some of them explosively loud from the conservative Hindu Jan Sangh party and the two outright Socialist parties,* but very few from the government of India itself. (Canadian clarity was increasing steadily from 1966 on.)

---

* The Samyutka Socialist Party (SSP) and the Praja Socialist Party (PSP).

In October 1966, India's representative to the United Nations' First Committee, Mr. Trivedi, protested against any attempt to prevent the development of nuclear explosives in the less advantaged nations. "..it had never before been suggested that there should be non-proliferation in science and technology. Technology in itself was not evil"* A few days later, he took an even bolder stand, justifying not only fission but also "controlled fusion explosions".**

> The non-nuclear-weapon Powers were irrevocably opposed to the proliferation of nuclear weapons. Such proliferation had, however, no practical connexion with the possible future use of nuclear fusion for the building of canals, dams or harbours...
>
> What was important was the question of principle; was it desirable, or morally defensible, to deny the benefits of the peaceful uses of atomic energy to other nations, particularly to the developing nations? The first impact of that question was whether countries should be allowed to develop their own techniques of controlled fusion for peaceful purposes; no developing country could accept a prohibition of such activity. Controlled fusion explosions must be adequately safeguarded, in keeping with the principle that atomic energy must be used exclusively for peaceful purposes. The Latin American States had suggested a system which would prevent any abuse of such peaceful undertakings; it was outlined in article 13 of the proposals for a treaty on the denuclearization of Latin America contained in the Final Act of the third session of the Preparatory Commission for the Denuclearization of Latin America (A/6328 and Corr.1). India agreed with the Latin American approach and believed that any State conducting such an explosion should announce it beforehand, make known its precise purpose and permit international observation and inspection.**

The 1970 program of the Department of Atomic Energy, mentioned earlier, was also a significant signal. Nuclear Engineering International has published*** a useful summary of that "imaginative" forecast of accomplishments

---

* Statement of Trivedi, Oct. 31, 1966, First Committee Meeting, United Nations General Assembly Twenty-First Session, New York, United Nations, 1967.

** Ibid, November 7, 1966.

***September 1971.

for the decade 1970-80. But even that magazine's traditional enthusiasm for the developing countries' participation in nuclear power dims a bit when contemplating India's projects for advanced thermal reactors and thorium breeders. It mentions the enormous investments in skilled manpower, training, research and development, manufacturing facilities, and the importation of foreign components required to establish an independent nuclear technology. However, it makes no reference to the military implications of the program for plutonium production, and no reference to the ambitious space program, which Dr. Sarabhai projected as follows:

> Augmentation of the facilities for R and D at the space science and technology centre to be able to build scientific and communications satellites and to environmentally test them; facilities at the Space Science and Technological Centre for the development of inertial guidance systems and on-board miniaturized computers; development at SSTC, TIFR and ECIL and construction of high-performance missile-tracking radars and PCM communication systems for installation at Shar and at Andamans in the Bay of Bengal for the satellite programme; construction of a plant for manufacture of large solid propellant blocks at Shar and a facility for static testing of these propellant blocks on the ground and under high altitude simulated conditions; completion of a rocket fabrication facility at Trivandrum for manufacture of large-scale rocket castings and hardware for rocket motors including the development of special materials for rocket motor systems; development of in-flight guidance systems for rockets; development in 1973-74 of a "scout"-type launcher of four stages, burning solid propellant, capable of putting into orbit a satellite of about 40 kg payload. This would be followed by development of more advanced rocket systems capable of putting 1,200 kg pay loads into synchronous orbits; fabrication of communication satellites by 1975 capable of providing high quality point-to-point service between metropolitan areas and direct

broadcast of television; development of sensors and techniques for remote sensing.*

Like the nuclear power program, the space program was nominally civilian, but was capable of having an obvious military application in developing ballistic missiles of short, intermediate and long range. The military aspect, of course, was clear to many Indians, and caused a furor of speculation in the press as to whether India had now changed her policy, because of two projects listed in the program: one the development of the technology of underground nuclear explosions and the other the development of gas centrifuge technology for the enrichment of uranium-235 with the overt object of "reducing capital costs in nuclear power production."** Prime Minister Indira Gandhi and Dr. Sarabhai felt obliged to go before the parliamentary consultative committee for the Department of Atomic Energy and reaffirm the government's commitment to a policy of "using nuclear energy for peaceful purposes only."*** Several members of the Consultative Committee had welcomed the projects as steps on the way to India's becoming a nuclear weapon state. But whatever the label, and however distant the completion, it was clear that both projects would be pursued with all deliberate speed.

---

* Report of the Atomic Energy Department, 1967-70 (New Delhi: 1970). Quoted by Wayne Wilcox in "Strategic Insurance for India," Survival, Volume XIV, Number 4, (July/August 1972), p. 179.

** Prithvis Chakravarti, "PM Affirms Underground Test in Order," The Hindustani Times Weekly, New Delhi, July 26, 1970.

***Ibid.

The military implications were not lost on the Canadians either. In the winter of 1970-71 the program aroused speculation and accusations in the Canadian press. On January 14, 1971, MP S. Perry Ryan rose on the floor of the House of Commons to ask Mr. Mitchell Sharp, then Secretary of State for External Affairs, "Is the minister in a position to assure the House that India is not producing and has not produced any weapon grade plutonium, Pu-239, since it was supplied with the Canada-India reactor in 1960?"*

Mr. Sharp delayed his answer until January 20, for the very good, if belated, reason that he "would like to find out exactly what this product is before answering the question." Clearly there could not have been much interest in atomic energy questions. Agriculture, fisheries, an oil pipeline, NATO and African affairs seem to dominate the debates at this time, and Pu-239 was a technical mystery. On January 20 Mr. Ryan rephrased his question in the form of requesting an assurance that "India has not produced weapon-grade plutonium since the Canada-India reactor was supplied in 1960?" The reply by Mr. Sharp (who meanwhile had found out exactly what plutonium-239 is) assumes that such production would be a violation of the 1956 agreement:

> In the 1956 Canada-India agreement for the provision of a nuclear research reactor the Indian government pledged that the reactor and the products resulting from its use would be used for peaceful purposes only. We have no evidence to suggest that the Indian government is not standing firm on the assurances it has given to Canada.

---

* Canada House of Commons Debates, 28th Parliament, Third Session (Ottawa: Information Canada, 1971) Volume III, p. 2406.

Mr. Ryan: Mr. Speaker, is the minister aware of the article by John Gellner in which he alleges that there is such a stockpile . . .
Mr. Speaker: Order, please.*

But order would not come.

Finally a formal announcement in September 1971 by the Chairman of the India Atomic Energy Commission at the Fourth Atoms for Peace Conference, that India had been working as a top priority in the field of Nuclear Explosive Engineering for peaceful purposes,** elicited a formal, direct response from Prime Minister Trudeau. He wrote to Mrs. Gandhi on October 1, 1971:

> You will remember in our talks (the previous January) I referred to the serious concern of the Canadian government regarding any further proliferation of nuclear explosive devices. The position of my government on nuclear explosions has been stated on a number of occasions and you will no doubt be well aware of it.
>
> The use of Canadian supplied material, equipment and facilities in India, that is, at CIRUS, at Rajasthan, or fissile material from these reactors, for the development of a nuclear explosive device would inevitably call on our part for a reassessment of our nuclear operation arrangements with India. (Toronto Star, July 11, 1974)

Observe Mr. Trudeau referred explicitly to the CIRUS research reactor. He was clear that the initial agreement of 1956 had never contemplated nuclear explosives under the rubric of "peaceful" actions. Clarification of the Indian understanding on this point was needed if the

---

* Ibid., p. 2587.

**R.V.R. Chandrasekhara Rao, "A View from India," Survival, (September/October 1974), p. 210.

Canadians were going to continue to give extensive assistance to India in the nuclear field. Mrs. Gandhi replied:

> The obligations undertaken by our two governments are mutual and they cannot be unilaterally varied. In these circumstances, it should not be necessary, in our view, to interpret these agreements in a particular way based on the development of a hypothetical contingency. (Toronto Star, July 11, 1974)

Of course if obligations under the original CIRUS or any later agreements were to be mutual, they had to be mutually understood in the same "particular way." To avoid "unilateral variations," the two sides would have to agree on one particular interpretation and that had better be done moreover in advance of the problematic contingency.

But the contingency was still, as Mrs. Gandhi suggested, merely "hypothetical." Apparently so farfatched that it was hardly worth discussion.

The United States joined Canada in approaching India at this time. As Myron Kratzer recently explained:

> In November, 1970, following a number of public indications that India would not regard development of a nuclear explosive device as inconsistent with a peaceful uses undertaking, an Aide-Memoire was provided to the Indian Atomic Energy Commission which stated, among other things, that "the United States would not consider the use of plutonium produced in CIRUS for peaceful nuclear explosives intended for any purpose to be 'research into and the use of atomic energy for peaceful purposes.'"*

However, in subsequent discussions "Indian authorities made it clear that they did not accept this interpretation of the 1956 contract. . . .

---

*Letter to Mr. Benjamin Huberman, Director of Policy Evaluation; Nuclear Regulatory Commission, from Myron B. Kratzer, Deputy Assistant Secretary, Bureau of Oceans and International Environmental and Scientific Affairs, Department of State, June 29, 1976. Hearings on S. 1439 by the JCAE, op. cit., p. 18.

U.S. officials concluded, at that time, that Indian officials appeared to be saying that India might elect to manufacture or otherwise acquire, nuclear explosive devices for peaceful purposes in the long term."*

As far as the United States was concerned, that is apparently where the matter ended, with resort as usual to the plea that the United States had no leverage in the matter.

After the event Mrs. Gandhi's supporters, who often used the language of disarmament, argued indignantly:

> It simply is not enough for Canadians to talk the disarmament language of the 1930s in the 1970s. Moreover, Indians want to know if it is right for a rich country to seek retroactive and unilateral interpretations of bilateral arrangements because of subsequent changes in policy.**

Unilateral and retroactive changes might be wicked even if made by a poor country. The rich Canadians however did not think that they had changed policy since 1956, only that they had made things more explicit. And they had for many years before 1974 been saying that there was no difference between "peaceful" nuclear explosives and the nuclear weapons which civilian programs had been intended to head off. After the explosion, Mrs. Ghandi with a practiced innocence, herself inquired, "Would they rather we exploded a nuclear weapon?"***

---

* Ibid.

**Ashok Kapur, "India's Nuclear Presence," The World Today, November 1974.

***"India is Angered by A-Test Critics." New York Times, May 26, 1974.

THE INDIAN TEST OF MAY 18, 1974

When the Indians detonated their first nuclear device on May 18, 1974, the code word flashed to the central government in New Delhi, "The Buddha smiles." Brilliant illumination in the dark depths of the Rajasthan desert gave a blessing to Indian inventiveness and independence. This was a truly Indian accomplishment--all materials and personnel used in the experiment were Indian. As reported at Dr. Sethna's press conference:

> India carried out an experiment of peaceful nuclear explosion at 5 minutes past 8 this morning in western India. The device was set off at a depth of about 100 meters. The plutonium device that was used for the explosion and the plutonium was Indian. The magnitude of the explosion was between 10 and 15 kilotons. The chairman of the Atomic Energy Commission, Mr. H. N. Sethna, told a press conference in New Delhi this evening that the explosion was an experiment to study the cratering and cracking effects on rocks. Not a single thing used in it was foreign.
>
> Mr. Sethna said at his press conference that the experiment carried out today was successful. There was no release of radio activity to speak of. After the device was set off a team of scientists made an aerial survey within 30 minutes. Even at a height of 30 meters there was no significant radio activity above the normal level. A certain amount of sand came up as the wind was blowing southwest. It (the sand) was chased by helicopter up to 40 kms but no radio activity was detected...
>
> Replying to questions by newsmen at Delhi Airport, where she had gone to receive the Senegal president, Mrs. Gandhi said there is nothing to get excited about the explosion. This is our normal research and study. It is an important step for the development of science in the country. Asked whether it will raise India's prestige, Mrs. Gandhi replied that she has never bothered about prestige.*

At the polls, 66 percent of the population voiced their approval.**An Urdu poem celebrated "those who tore asunder the heart of the atom" and the lady who gave the "go" signal for this "flower of peace": a "golden dawn"

---

* FBIS - 20 May 1974. Later explanations managed to produce a somewhat more impressive list of uses and results, although Dr. Sethna indicated that "the actual peaceful application of the Pokharan atomic explosion technology might take a decade or more" April 17, 1975, Hindustani Times.

** "Indians are Hawkish on A-Power". Philadelphia Inquirer, 31 July, 1974, p.6D signaling the end of grinding poverty.* (Our own first Trinity test had inspired a similar lyricism in a War Department press release, and led Robert Oppenheimer to recall fragments of the Gita.)

An awesome stillness fills the air
A fearful tremor shakes the earth's core
And the rays of the sun go in a mad dance
The word of Truth
Becomes a thunderous echo.

From across the desert wastes the breezes waft glad tidings
Of the birth of a new age;
Of the blossoming of a new flower, the flower of peace
And then carries its fragrance to distant lands.

The dismal darkness of grinding poverty
Gives way to a golden dawn
Of new hopes and triumphal rejoicings.
Though after every night comes the morn
This day is like no other day before.

Those who burnt the midnight oil and sweated blood
Who gave the light of their eyes to make a brighter day
Those who tore asunder the heart of the atom

To achieve this final victory
And to her who gave the first signal
To all of them,
Felicitation and salutation.

The lovely dream that Jawahar once dreamt
Has lit the gardens of our native land.
Go spread the news to all our neighbours
Tell them it is springtime, the season of friendship and amity
Tell them to banish fear and hatred from their hearts
For life hath no meaning without love and charity.

by Sikander Ali Waja

Translated from the Urdu by Khushwant Singh

Elsewhere there was not exactly the same sort of rejoicing. Pakistan as might be expected, reacted with sharp disapproval. That country had attempted

---

*The Illustrated Weekly of India, July 14, 1974.

to slow the Indian nuclear program during the conflict with India in 1965 by stealing a large number of parts destined for the Tarapur reactor.* Prime Minister Bhutto, long an advocate of a nuclear weapons program for Pakistan, called the Indian explosion a "fateful devlopment", that introduced a "qualitative change in the relation between the two countries."** He vowed that Pakistan would be "no victim of nuclear blackmail", and his chief of staff, Tika Kahn, threatened that if India were to develop a nuclear arsenal, "we will have to beg or borrow to develop our own nuclear capability."***

India's other immediate neighbors were rather more reserved. The Bangladesh Government accepted Mrs. Gandhi's assurances on peaceful purposes but added that "any advance into nuclear weapons would be a different story."**** Nepal's representative to the United Nations was quoted as saying, "Nepal is of course against all forms of proliferation and is against nationally conducted explosions."+ Ceylon proposed in the United Nations that "the countries of the region commit themselves to a policy of denuclearisation which would entail the permanent renunciation by them of a nuclear weapon option."++

---

* International Agreements for Cooperation - 1966. Hearings before the Subcommittee on Agreements for Cooperation of the Joint Committee on Atomic Energy, May 26, 1966. USGPO, 1966, p. 45

** The Times of India, May 23, 1974, and Karachi Overseas Service, 5/19/74.

*** Kahyan International, March 7, 1975.

****Bangladesh Observer, May 20, 1974

\+ November 11, 1974, A/C1/ PV 2016, U.N. General Assembly, New York.

++ Ibid. PV 2015.

At a greater distance, Japan condemned the explosion as "breaking a taboo"; South Korea was noncommittal, but a South Korean delegation visiting the U.S. in June professed that "we are capable of developing nuclear weapons whenever we want to"*, and stressed that there would be no other option if the U.S. abandons Korea. Australia responded somewhat more favorably, "For the time being we must take at face value India's protestations that it is interested only in acquiring a nuclear expertise for peaceful purposes, not in acquiring a nuclear arsenal."** André Giraud, Chairman of the French Atomic Energy Commission, sent congratulations to India's scientists (although he has since had second thoughts), while the Soviet Union uttered some words of mild approval for a technological advance.

Canada's reaction was understandably the most severe, since she had been a principal supporter of India's nuclear program and a recipient of assurances that plutonium from the CIRUS reactor would not be used in a nuclear explosive. On May 19, 1974, Mr. Michell Sharp, then Minister for External Affairs, once again made clear that Canada saw no distinction between the development of nuclear explosions for "so-called peaceful purposes" and explosions for military purposes, and a few days later announced that Canada was discontinuing its program of nuclear collaboration with India, pending the outcome of discussions aimed at bringing such collaboration under more stringent safeguards. These negotiations failed, and on May 18, 1976, Canada formally terminated cooperation with India in the nuclear field.

---

* FBIS, 16 June 1974

** The Australian, May 1974

The first reactions, then, covered a wide range. The innocent Indian claim that their nuclear explosion was a contribution to peace stimulated immediate forebodings among countries in the region, including potential adversaries, with indications that some might follow in India's footsteps. Remoter countries suggested that they might not respond as a counter to the Indian program, but in imitation of it for their own self-defense, if alliance protection were to weaken. Supplier countries had a very mixed reaction, varying from the nostalgic Gaullist response by the head of the French atomic energy program congratulating the Indians on their technical feat and the expedient reaction of the Russians, to the shock of the Canadians -- all of this immediately. But with time the significance became more apparent. It was the first brazen use of a civilian program to achieve the most important military application, namely nuclear explosives, clearly violating the common sense meaning of agreements and presenting an obvious danger to the intent of all such agreements, especially if the explosion were ignored, condoned or apologised for. It was a demonstration of the vulnerability of all agreements for peaceful or civilian use only of nuclear energy, if the other parties to the agreement did not act forthrightly so as to exclude or penalize civilian programs which also had an obvious, essentially military use.

AMERICAN REACTIONS

In the United States at first shock combined with cynicism about India's peaceful intent. But officially the United States government tended to let it rest as a matter between India andCanada and their specific contractual arrangement. U.S. involvement, it was said, applied only to the Tarapur Power Station--an interpretation that coincided happily with India's. U.S. heavy water provided for the CIRUS reactor was not mentioned, except by the Canadians, and that with restraint. India announced that the Bilateral Agreement with Canada on the CIRUS reactor terminated with the first load of Indian rather than Canadian fuel. Indeed any attempt to define Indian behavior as in violation of any agreement, American, Canadian, or IAEA, met with the same legalisms and furry talk that has characterized the history of our relations with that country. Indian bickering and redefinitions have left their mark on many negotiations and institutions involving atomic energy, including those, like the NPT, to which India is not a party. The long history of negotiations has left as heritage a cloud of ambiguities and quibbles thick enough to shroud any response except the most determined.

Nevertheless, the shock expressed in Congress intimated to the State Department and to the AEC early in the summer of 1974 that it might be translated into some sort of sanction against India. It became important from a purely defensive standpoint for the bureaucracy to establish the claim of India that only Indian materials had been used in making the explosive device, since this would ward off the pressure for Congressional investigations and possibly for sanctions, all of which would exacerbate our recently troubled relations with that country. Canada had reacted immediately by suspending nuclear assistance toward completion of the Rapp II reactor at Rajasthan. Members of Congress were wondering privately and publicly about one obvious course for the United States--a cutoff of fuel reloads for the Tarapur Station. This sort of sanction had always been mentioned in the past as the natural first result of any violation of an Agreement for Cooperation with the U.S., short of the more severe sanction of withdrawing material and equipment.*

* See for example <u>International Agreements for Cooperation</u>, <u>op.cit</u>. pp. 131-2. Mr. A. A. Wells in answer to Representative Hosmer's question, "What is our recourse in the event we discover a violation...of a bilateral agreement?" "One of the first things that we would do, it seems to me, would be to recall the material...the main reliance would be to declare the agreement null and void and ask the country to return the material...it would bring down on them some very dire consequences."

It was natural, for example, that the House Committee on Appropriations for FY 1975 should be concerned. Representative Clarence Long of Maryland on June 3, 1974, inquired of Secretary Kissinger whether the Indian explosion would affect our $75 million program of assistance to India, and if so, how. The Secretary replied that we had reaffirmed our basic opposition to nuclear proliferation but had not changed our "basic position on aid to India." Our position at the Indian aid consortium meeting in Paris in June would depend... It would depend on the "progress of our discussions with the Indians".* In addition the Secretary recited Article IV of the Non Proliferation Treaty, pledging the fullest possible exchange of technology and equipment for the development of peaceful uses of atomic energy with due consideration for the needs of the developing areas of the world. He implied, in short, that the Indian explosion was not likely to hinder continuation of our nuclear aid to India.

Representative Long, however, returned with greater insistence to his questions on June 11, when Daniel Parker, the Administrator for AID, appeared to testify. Representative Long first wanted to know why the Indians had chosen nuclear power. "They are capital-intensive sophisticated installations, and I wonder why a very poor country, one of the poorest on the earth per capita, has to go in for this kind of thing instead of some of these traditional power plants."** In answer, Mr. Parker referred to the Burns and Roe report which we discussed earlier. His analysis is as follows:

---

* U.S. Congress, House of Representatives, Committee on Appropriations, Hearings on Foreign Assistance FY 1975, June 3, 1974. USGPO, 1974. p.57.

** U.S. Congress, House of Representatives, Committee on Appropriations, Hearing on Economic, Security Supporting, and Indochina Postwar Reconstruction Assistance and the Middle East Special Requirements Fund. June 11, 1974. USGPO, 1974, p. 320

Economic Analysis: Nuclear Power Development Versus Hydroelectric or Thermal Power Development in India

The Tarapur proposal was the result of about 4 years of intensive study on the part of the Indians, culminating in the conclusion that atomic power generation should be developed to lessen dependence upon high-cost fossil fuels. Tarapur, which serves the Bombay-Ahmedabad region, is in a high-cost fuel area. Known reserves of oil and gas for power generation are limited; and coal reserves, although apparently in abundance in India, are not located in the proximity of Tarapur. The nearest coalfield is about 500 to 600 miles away, making coal as an energy source for these Indian states a highly costly commodity.

An economic appraisal of the project conducted by Burns & Roe, Inc. consulting engineers retained by AID, indicated that a nuclear plant would be competitive with a conventional power station serving the same area. While the nuclear station would involve a larger initial capital investment than a conventional thermal station, the study showed that costs for fuel, operation and maintenance would be lower--$8 million per year for nuclear power versus $13.8 million for a coal plant and $10.9 million for an oil plant. In addition, the annual foreign exchange outlay for imported fuel would be about $4 million less for a nuclear plant than for an oil-tired thermal plant. The economic analysis also showed that the costs of operation and rates to be charged for power sales would be reasonable. Estimated sales at such rates would yield sufficient revenues to cover all operating and maintenance expenses, and amortization and interest costs, and to earn a profit.

Prospects for constructing a hydroelectric plant in lieu of an atomic powerplant were also studied and dropped because the main hydroelectric resources in the area were already being put to use, and any unexploited hydro potential could not be engineered and completed in time to meet the power requirements of the area. As noted above, the limited amount of gas produced in the area, all of which was destined for existing power stations, fertilizer plants, and industrial establishments, made consideration of a gas-burning plant an impractical alternative.

By the 1960's when the Tarapur project was developed, India had already attained a high degree of nuclear technology. It had a trained staff of about 1,400 Indian scientists and engineers, and three experimental nuclear reactors in operation--two built with Canadian assistance and one of Indian design and manufacture. Given these considerations and the fact that atomic power even in this country was considered a necessary supplement to power from conventional sources, financing for the Tarapur project was approved.*

---

*Ibid, p. 320

98

Some major defects in the Burns & Roe report were apparent in the mid-1960s. (Witness the devastating analysis by Dr. William Hoehn cited above p. 78). Moreover history has been unkind to it. The supposedly plentiful supply of native nuclear engineers and scientists has produced a sad record of maintenance at India's nuclear facilities. Nonetheless the Burns & Roe report of 1963 remained the undisputed authority in 1974.

Representative Long also wanted some technical information on the amount of plutonium produced in the Tarapur reactor each year. The answer was provided by the international division of the Atomic Energy Commission.

> The Tarapur nuclear power station (two reactors), produces plutonium at the rate of approximately 120 kg. per year, depending upon the degree of operation. While the plutonium produced by these reactors could be used in an efficient*and unsophisticated explosive program, according to the Atomic Energy Commission, it is not optimum material for explosive uses because of the high percent content of the nonfissionable plutonium isotope Pu^{240}. This content is typical of the plutonium produced in power reactors. However, our safeguard agreement with the Indian Government precludes even such theoretical use of the plutonium produced.**

Plutonium 240 is of course fissionable, and though not as readily fissionable as Pu239 or Pu241, it is fissionable in the bomb. What is troublesome is its high rate of spontaneous fission, but that does not prevent it from being usable in a primitive implosion device, (like our Trinity or Nagasaki bomb), with formidable military utility.

The answer given by Mr. Parker is one of a series of excessively reassuring government answers on the use of power reactor plutonium -- a sequence which seems finally to have been terminated in November 1976.

---

* sic. The original answer supplied by Mr. R. Willet, now of Nelson Sievering's shop in ERDA, said "inefficient". AID open file on Tarapur.

** House Committee Appropriations, June 11, 1974, op.cit. p.321.

We now make unambiguously clear that power reactor plutonium can be used in a nuclear explosive of no great sophistication, and that it will nevertheless reliably yield a kiloton or so, and probably much more. In June of 1974 this danger was muffled and then forgotten in a discussion about safeguards against diversion of plutonium from the Tarapur. Mr. Parker spoke on his own about why the safeguards would be adequate and once again was excessively reassuring. "I believe," he said, "that there is provided both direct supervision as well as the calculated knowledge on the assumption of what plutonium would be produced as a consequence of the peaceful uses with utilization of nuclear materials. This must reconcile with the accounting which is given for the handling of it. *I believe it is required to be returned to the United States.*"*

It might have been required, but unfortunately is not. According to our Agreement for Cooperation, title to the plutonium resides in the recipient of enriched uranium fuel. When the Indians first negotiated the agreement, and again in 1973, they suggested returning the spent fuel in a buy-back arrangement. The United States declined for two reasons: 1) they didn't need it, and it would be an expense to buy it back, and 2) if the safeguards arrangement negotiated eventually required U.S. inspection to satisfy Indian demands for "equality", then that might lead to inspection of our

---

*Ibid. p.322. Italics added

plants producing plutonium for weapons purposes, and that would be unacceptable to our Defense Department.*

Congressman Long also wanted to know about India's intent to develop nuclear explosives; "When was the date India announced or implied that it would develop nuclear explosive devices?"** The information follows.

---

* See page 68 of this chapter, and see also the memorandum of April 12, 1963, to N.D. Bengelsdorf, from N. Stetson, op.cit., "...problems of classification and security exist...I assume that the AEC is not obligated to process fuel or purchase plutonium. If this is the case, the AEC could refuse to accept fuel from Tarapur and thus avoid having the AEC facilities involved."; or the memorandum to A. A. Wells, Director Division of International Affairs, from Paul C. Fine, Division of Operations Analysis and Forecasting, on the same subject on the same date: "...I believe that it is no longer desirable for the United States to purchase plutonium from foreign countries," or to Mr. Wells on April 15, 1963, from R. Carson Dalzell, Assistant Director for Foreign Activities, DRD: "Plutonium returned from foreign sources might be an important part of 'civilian power plutonium' in the U.S. in a few years. Unless the Commission assures DRD of a continued supply of unclassified domestic plutonium, it would appear possible that we would have to use the imported plutonium in the AEC experimental reactor program.

"If imported plutonium is under safeguards control, and if present procedures are applied, our experimental flexibility would be impaired. It would be necessary for us to secure foreign approval for design changes and program changes. We consider this objectionable and we wish the Commission to consider this possibility in evaluating the pros and cons of the action recommended in your staff paper."

**Ibid., House Committee on Appropriations Hearing on Economic Security Supporting, op.cit., June 11, 1974, p.326.

Indian Intention to Develop Peaceful Nuclear Explosion

India, for a number of years, has talked about the possibility of exploring the technology of peaceful nuclear explosions. One of the earliest official statements in this regard was made on August 2, 1972, when Mrs. Gandhi, in reply to a parliamentary question on whether the government was looking into the feasibility of underground nuclear explosions for minerals extraction, said that "the Atomic Energy Commission is studying situations under which peaceful nuclear explosions carried out underground can be of economic benefit to India without causing environmental hazards." In a later statement to Parliament on November 15, 1973, however, Mrs. Gandhi denied that any final decision had been taken to conduct experiments to develop nuclear blast technology for peaceful purposes.

Mr. Long. Didn't India make an announcement which presented us with a fait accompli?

Mr. Parker. That is my understanding?

Mr. Long. That is the first we heard of it. Was there any other indication before that? If you find any, please put that in the record.

[The information follows:]

U.S. Knowledge of Indian Nuclear Test

The United States had no prior knowledge that India was planning to explode a nuclear test device, nor were we informed beforehand that such a test was about to take place.*

As in all cases of surprise, our intelligence sources did not pick up a message announcing the precise date of the explosion. But a Congressman would have to be naive in the extreme to accept this as an explanation for the surprise. Our problem was not so much a lack of knowledge as it was a lack of clear policy for doing anything about it, in case an explosion occurred. A second Indian explosion in the year following might have found us no better prepared to respond. Indeed, two years later the State Department was still defending shipments of fuel to Tarapur on the grounds that the U.S. must be a reliable supplier. In June of 1974, however, the supply apparently continued automatically.

---

* Ibid, p.236

Our Agreement for Cooperation with India had been implemented so as to provide regular shipments of enriched uranium fuel to the Tarapur reactors.* The consignment immediately following the Indian explosion was for the period, June 15, 1974, to April 1, 1975, to be delivered in five separate shipments. Consequently, arrangements had been made before the Indian test for shipping the first portion on or about June 15. The communications between Dr. Sethna, Chairman of the Indian AEC, and Dr. Dixy Lee Ray, Chairman of the U.S. AEC, indicate that the scheduled date for shipping was June 17, and apparently the shipment went out at about that time, despite some AEC and Congressional hesitations. For in any bureaucracy, when provision is made for certain procedures, they will be taken automatically, unless an emergency has happened of truly awesome dimensions, breaking down communications, the offices and the officers themselves.

In the case of the Indian explosion, which would seem a crucial, even if not an awesome, event, the bureaucracy was reinforced by a message recorded on June 12 from the "White House in Salzburg"** that the Tarapur shipment should not be held up for "political reasons"; on the other hand, if there were "technical problems with the safeguards," the shipment

---

**Secretary Kissinger

*As of April, 1976 India was the only country that had an agreement for cooperation with the United States, where the United States ~~has~~ undertakes a legal commitment to provide up to a total of 14,500 kg. of U-235 (to fuel the Tarapur reactors), ~~ERDA~~ ~~3.3.2.1.1 of~~ provided of course that there has been no violation of the agreement. ERDA, U.S. Nuclear Power Export Activities, Final Environmental Statement, April 1976, Volume I (ERDA 1542-UC-2) 3.3.2.1.1.

might be held up.* India has a rich history of technical violations, particularly in the area of reporting the receipt of special nuclear material, but the unclassified record does not show any technical safeguard problems in June of 1974.

The message from Salzburg distinguished "political" from "technical" reasons, but did not explain that distinction. "Technical" sometimes means the same as "minor," as in technicality"--which meaning would have suggested holding up the shipments only for trivial reasons. While on the face of it that might seem odd, it is not entirely so, since a holdup premised on minor technicalities could be quickly reversed. On the other hand "political" reasons would be deeper, more comprehensive and rather more vague, and the determination of adequate political reasons surely seemed out of the hands of the Atomic Energy Commission, and possibly rested only in Salzburg. Moreover, the message had said "technical problems with the safeguards." The explosion had been made with material produced in the CIRUS research reactor which was moderated with U.S. heavy water, and the heavy water was under a peaceful use constraint. However, the United States relied on the good faith of the Indians in living up to that constraint. There were no safeguards on the heavy water in the CIRUS reactor, and even if there were, the message from Salzburg was that the only reason delaying the reload would be a tech-

*Memo of Dixon B. Hoyle to A.S. Friedman, June 12, 1974. Mr. Hoyle was Assistant Director for Supply and Market Policy, Division of International Programs; Mr. Friedman was then Director of International Programs (DIP) of the AEC, now ERDA. See Appendix F.

nical one connected with the safeguards on Tarapur. The Indian nuclear explosion could not possibly be connected with safeguards of any sort, much less those at Tarapur. So what the message implied was: do not hold up the reload because of the nuclear explosion.

Perhaps the most important decision implicit in this message from the Salzburg White House was to separate entirely the violation in CIRUS from the question of continued nuclear assistance at Tarapur. This contrasted in principle with the Canadian reaction to the explosion which clearly recognized the relevance of India's violation of the agreement on CIRUS to the question of Canadian assistance on the heavy water power reactors at Rajasthan, in particular the construction of RAPP II which was unfinished.

The U.S. decision to play our response in a low key was reflected in the Department of State press guidance. The two sentence suggestion made no reference to the Indian explosion, to the CIRUS, to our heavy water or to our continued cooperation at Tarapur. It merely expressed our exemplary sentiments about nuclear proliferation: "The United States has always been against nuclear proliferation for the adverse impact it will have on world stability. That remains our position." Secretary Kissinger remarked in the same vein at his press conference of June 7, 1974,

> I do not believe that the Indian nuclear explosion changes the balance of power, though if India had asked our advice we would probably have not recommended it. But we do not believe it changes the balance of power since its resources will be relatively limited. Nevertheless, we are opposed to proliferation.
>
> I have had to delay my trip to India not as a result of the nuclear explosion but as a result of the extension of the Syrian-Israeli disengagement talks; and I still plan to visit India in the relatively near future.

Low key diplomacy has its attractions. "Pas trop de zèle," Talleyrand advised diplomats. But so muted a response could hardly have helped muster world opinion for even the mildest of sanctions for India's violation of its peaceful use only constraint. And there is no evidence in the substantial files that have been released since the explosion that our private representations to India were more severe.

In accordance with the Salzburg directive, on June 19 Dr. Ray sent a letter to Dr. Sethna to inform him that the first part of the shipment was on its way and to request an assurance from the Indian government--prior to the date of the next scheduled shipment--"(1) that the use in or for any nuclear explosive device of <u>any material or equipment</u> subject to United States Agreements for Cooperation in Civil Uses of Atomic Energy is precluded; and (2) that under the safeguards agreements related to such Agreements for Cooperation, the IAEA is responsible for verifying, inter alia, that the safeguarded material is not used in or for any nuclear explosive device." (italics added)

The four other commissioners concurred. Commissioners Anders and Doub, however, noted wistfully that they "would have preferred withholding [the] current initial shipment until [a] response from [the] Indians was obtained." *

Dr. Sethna's response came in due time. It was entirely in keeping with the history of Indian resistance to safeguards. On July 10, the Indian Ambassador in Washington, Mr. Kaul, delivered to the State Department Dr. Sethna's regrets that the Government of India "is unable to share the understanding of the United States Government." This understanding, he believed, "does not flow from the Agreement for Cooperation between the two Governments concerning the construction and operation of the Atomic Power Station at Tarapur." The safeguards, he pointed out, are relevant only insofar as they apply to the fuel, not to the facility, at Tarapur.

---

* Handwritten marginalia on the ERDA copy.

> Under Article VI, the parties to the Agreement have emphasized their common interest in assuring that any material, equipment or device made available to the Government of India for use in the Tarapur Atomic Power Station, or in connection therewith, pursuant to the Agreement shall be used solely for peaceful purposes. However, the Government of India had emphasized in this Article, in contrast to the position of the United States, that its agreement to the provisions of Article VII was accorded in consideration of the fact that the Tarapur Atomic Power Station will be operated on no other special nuclear material than that furnished by the United States Government and special nuclear material produced therefrom. The safeguards provisions of Article VI of the Agreement for Cooperation were later on transferred under a Trilateral Agreement to the International Atomic Energy Agency.

He also drew attention in particular to Clause F of the Agreement with the U.S., whereby the U.S. has the first option to purchase special nuclear material produced in the Tarapur reactors which is "in excess of the need of the Government of India for such material in its programme for the peaceful uses of atomic energy . . . except a quantity which could be required for recycling in the Tarapur Atomic Power Station as provided under Clause A of Article II, the amount being arrived at after mutual consultation." With ~~a chutspa~~ an arrogance that only the Indians can manage, he suggests that "in case the U.S. Government wishes to incorporate changes in the existing Agreement, that we meet and discuss this matter?"

In the meantime, Secretary of State Kissinger had returned from Austria, and sensitive to the alarms in Congress, inquired himself of the Indian Ambassador in early July as to whether or not only Indian material or equipment had been used in or for the nuclear explosion. He received a reply on July 6 from Mr. Kaul that "The Indian Government used only '100% Indian material, Indian personnel and Indian technology' for the nuclear explosive device detonated on May 18, 1974.

At a dinner party on July 15, the Indian Ambassador and Dr. Kissinger apparently pursued the subject again. Their conversation resulted in a letter from the Indian Ambassador on July 18 enclosing a copy of Dr. Sethna's July 10 letter and repeating the assurance that India had not violated any of the provisions of its Tarapur Agreement with the United States and that it intended to abide by that agreement. He is worried about India receiving the "material" without delay and claims that because of the delay "the plant has had to be temporarily closed." If the Ambassador was referring to the next fuel shipment, it would be charitable to suppose that he was misinformed. An Indian inventory completed in March of 1976 showed a supply of enriched uranium of at least two years on hand, which would mean that we would have had to step up our shipments after the explosion rather than delaying any of them. However, it is possible that by "material" he meant the replacement of "four nuclear sensors," which were being delayed prior to a clear understanding with the Indians.

So Chairman Ray tried once more to get an unambiguous statement from the Indians. But this time she sent a draft of a letter for Dr. Sethna's approval, to maintain the written record of Inidan cooperativeness. She wrote:

<u>D R A F T</u> (no date)

Dear Dr. Sethna:

Thank you for your letter of July 10 responding to mine of June 19 concerning shipments of enriched uranium fuel and other materials to the Tarapur atomic power station.

Your response leads us to believe that we may not have made sufficiently clear the nature of the assurance we need. What we ask is simply written assurance from your government that the special nuclear material that has been or is hereafter made available for, or used or produced in, the Tarapur atomic power station will be devoted exclusively to the needs of that station or other agreed purposes that do not include use in a nuclear explosive device.

We look forward to hearing from you on this in order that we may promptly proceed with further shipments.

Sincerely,

Dixy Lee Ray

The Indian Embassy got around to delivering a reaction to this draft on August 27. They said they would like to drop the phrase "purposes that do not include use in a nuclear explosive device."

The State Department obligingly suggested another wording (approved informally by the National Security Council) that made no mention of a nuclear explosive, but referred instead to "other purposes which will be mutually agreed by the two governments." That would seem a vague enough statement for the peaceful government of India to sign. But it took still more time to reach agreement.

Along about September 10, or perhaps earlier, the Indians approved a statement that the special nuclear material would be devoted exclusively to the needs of the Tarapur station "unless the two Governments hereafter specifically agree that such material be used for other purposes."

This incident is typical of Indian behavior, trying to be legally correct in manufacturing their next nuclear explosive, and still going along with the U.S. government enough to ensure that India gets its enriched uranium. That intention is perfectly clear in the refusal not only to sign a letter that refers specifically to a nuclear explosive device, but also the refusal to sign a letter referring to "mutually agreed purposes." That would imply that the government of India currently agrees with the U.S. government and it does not. That is why the final wording refers to an agreement that will have to be worked out in the future (hereafter) and therefore leaves intact the Indian understanding of their current Agreement for Cooperation with the U.S.

For the record, however, in public the exchange of letters officially took place in Vienna. On September 16 Dr. Ray handed a letter to Dr. Sethna, while they were both attending the IAEA General Conference, and on September 17 Dr. Sethna handed in his reply.* Dr. Kissinger pronounced the final benediction on the Indian explosion by announcing in his speech in New Delhi on October 28 of that year, "We take seriously India's affirmation that it has no intent to develop nuclear explosives.** And there the matter would have rested, had it not been for the persistent pressure of certain members of Congress.

In the past the Joint Atomic Energy Commission had tended to dominate Congressional discussion of nuclear matters, and in the earlier, more carefree period before the Indian explosion, had been a principal sponsor of the propagation of nuclear exports, with a steadily weakening interest in control. Indeed, a former Executive Director of the JAEC staff,

---

*See Addendum F for this series of exchanges.

**New York Times, October 29, 1972 1974

James T. Ramey, became a Commissioner of the Atomic Energy Commission and in his role as a Commissioner had been a principal sponsor of the Indian program.

After the Indian explosion, concern about the dangers it symbolized stimulated a much wider questioning, engaging the interests and energy of other Committees in both the Senate and the House: for example, the House International Relations Committee, the House Committee on Interstate and Foreign Commerce, the House Committee on Appropriations, the House Committee on Interior and Insular Affairs, the Senate Committees on Government Operations, the Senate Committee on Foreign Relations, the Senate Committee on Banking, Housing and Urban Affairs, etc. The initial focus was domestic and centered on the possibilities of nuclear terror, but there followed a deepening recognition of the problems involved in the spread of special nuclear material to non-weapon states. This movement led ultimately to the demise of the Joint Atomic Energy Committee and a division of its powers among a variety of House and Senate Committees.

The Senate Committee on Government Operations, for example, exhibited a continuing interest in the subject of proliferation, and Senators Percy, Ribicoff and Glenn of that Committee introduced on April 15, 1975, a bill, S-1439, designed to reorganize U.S. nuclear export procedures. The Committee held three days of hearings in April and May of 1975, which resulted in a new Committee print of S-1439 on January 8, 1976, followed by another set of hearings in January and March, 1976. The question of continued U.S. nuclear cooperation with

India after the Indian explosion naturally came up for reexamination. It is interesting that by March of 1976, Secretary Kissinger was under the impression that the United States had reacted quite vigorously in denouncing the Indian bomb.

> Senator Percy. What was the official U.S. reaction to India's explosion? It would seem that there was very little comment on it. Was a private representation made to India? Did Canada carry the load on that?
> Secretary Kissinger. No, we *deplored it strongly*, and we have made clear to India that we saw no need for it.*

Nevertheless, Canada did continue to carry the load on India's use of Canadian and American peaceful aid for the purpose, unenvisaged at the time the aid began, of making a nuclear explosive. The State Department position remained the same: India had not violated an agreement with the United States. The Secretary said, "We objected strongly, but since there was no violation of U.S. agreements involved, we had no specific leverage on which to bring our objectives to bear."**

Senator Glenn pressed a bit farther, "Even though they did not break the agreement with Canada per se, they certainly broke a moral commitment that everybody thought they had to the world. And still we are shipping them fuel, as I understand it."***

Moral commitments are often more honored in the breach than in the observance, but there is a gray area in the definition of an agreement between its obvious common sense meaning, whether or not spelled out explicitly, and a loosely defined spirit of cooperation that might go with it. Not just the spirit, but the common sense

---

* U.S. Senate, *Hearing on S-1439, Export Reorganization Act of 1976*, Committee on Government Operations, March 9, 1976, USGPO, 1976, p. 793. Italics added.
** *Ibid*.
****Ibid*., p. 795.

meaning of any agreement to limit cooperation exclusively to peaceful applications would surely exclude any application as directly usable in war as a nuclear explosive. (The legislative history of the changes in the Atomic Energy Act in 1954 and of the U.S. sponsorship of the International Atomic Energy Agency show clearly that Congress understood that our transfer of American nuclear technology would be such as to discourage the belligerent uses of nuclear energy, even though we were propagating its civilian applications.)* But the Secretary did not face even the more kindly suggestion of Senator Glenn that the Indians had violated the spirit, and thus ~~its~~ their moral commitment. The Secretary did not talk about the spirit of CIRUS, only the letter of Tarapur. And he did not talk about India's obligation to Canada or to the world. He pointed out once again that the Indians had not broken the letter of their Tarapur agreement with us.

"We have a nuclear fuel contract with India which however does not contribute to their capability in the nuclear field."**

---

* See, for example, the questions of Senator Sparkman, ~~etc.~~ et al. at the Senate Foreign Relations Hearings on the IAEA Statute, May 1957, USGPO, 1957.) Senator Sparkman asked, "Just what certainty is there that a particular peacetime project might not have a future military use as well as a peaceful one?" Secretary Dulles deferred to Chairman Strauss but gave his "untutored impression that since the material furnished will not itself be of weapon quality, and since the making, converting of it into weapon quality or the extraction of weapons quality material out of it as a byproduct would be an elaborate and difficult and expensive operation, that could not occur without the knowledge of the agency and that the violation would be detected," p. 14.

**U.S. Senate Hearing on S-1439, Export Reorganization Act of 1976, op.cit., p. 795.

Besides ignoring the fact that even at Tarapur the spent fuel contains plutonium and might therefore contribute to a military nuclear program, Dr. Kissinger's reply implicitly assumes exactly the opposite of what Senator Glenn assumed in asking his question, namely that what the Indians do in violation of the spirit or letter of their agreement on CIRUS with Canada or on heavy water with the U.S. should affect our continued cooperation on the Tarapur reactors. For Dr. Kissinger these two matters are independent: the agreement on Tarapur is about fuel for the Tarapur only and has nothing to do with the CIRUS.

There was a policy choice available to the United States and Canada in response to the Indian explosion. One course of action--undertaken by Canada immediately, and confirmed two years later, and then extended to other countries--would be to premise further nuclear cooperation with non-weapon states not merely on their literal fulfillment of one specific contract or agreement or even their fulfillment of all agreements with one's own government, but on their entire nuclear program and on the question as to whether it was serving exclusively peaceful aims or was advancing military ones also. The Canadians stopped work under their agreement for the Rajasthan (RAPP II) power reactor immedately after the Indians had exploded a nuclear device, even though it was plain that RAPP II had nothing directly to do with that explosion. In May 1976 they refused finally to renew cooperation with India, since India refused to abandon its nuclear explosive program, but only to defer it until completion of RAPP II.

Since then Canada has refused cooperation with such countries as Pakistan, which have refused to disavow nuclear explosives.*

It is clear that the trend of Congressional questioning was pressing in the direction of a course of action similar to Canada's. The State Department, however, chose a course of action justified entirely in terms of our supposed legal obligation under our bilateral agreement with India on Tarapur and under our trilateral one with India and the IAEA. More disabling still, it suggested that if we withheld one shipment of fuel for the Tarapur we would be in violation of our agreement with India, and that therefore the Indians would be free legally to use the plutonium accumulated from all the fuel that had passed through the Tarapur reactor up to then.** In short, in its brief for this shipment it ignored India's use of Canadian and American help at CIRUS and implicitly suggested that the fault would be ours, not the Indians', if we didn't ship them more enriched uranium fuel.

Senator Ribicoff was not to be put off with this explanation. He returned to the connection between the U.S. agreements on CIRUS and on Tarapur. If the letter of the contractual arrangement for Tarapur was so important, then what about the earlier contract between the U.S. and India on the sale of heavy water for CIRUS? The Senator requested first of all "the specifications, and the agreement and export documents, relating to the transfer to India of heavy water that was subsequently used in the CIRUS research reactor." ***The State Department replied that ERDA had been able to locate only the "March

* The Energy Daily, Dec. 17, 1976, p.4. "Canada's Nuclear Export Stand Toughest Yet."

** U.S. Senate Hearing on S-1439, Export Reorganization Act of 1976, op.cit. p.856.

***Ibid. p.852.

16, 1956 Agreement (Contract) itself. Since the transaction was on a Government-to-Government basis," Mr. McCloskey, the Assistant Secretary for Congressional Relations, explained, "no export licenses were involved. Normally, under these circumstances, a letter was prepared advising the Collector of Customs at the port of export of this fact; ERDA has not been able to furnish this document, however."*

Senator Ribicoff wanted to have also "a summary of the peaceful or civil use understanding with India regarding utilization of the heavy water, including any explicit or implicit reference to peaceful nuclear explosions." Mr. McCloskey replied that the Agreement for the sale of 21 short tons (42 thousand pounds) of heavy water "stipulated that the heavy water was for use only in India by the Government of India in connection with research into and the use of atomic energy for peaceful purposes. It was further agreed that the heavy water should be retained by the Government of India or by other parties authorized to receive it, and should not be resold or otherwise distributed. There was no explicit or implicit reference to peaceful nuclear explosions in this agreement." It seems that "the concept of a peaceful nuclear explosion had not been developed at that time."**

The Senator also wanted "a description of the circumstances surrounding the U.S. supplied heavy water during and after the time

---

* Ibid., p. 852. The March 1956 Agreement is reprinted on pp. 857-859.

**Ibid., p. 852.

that the CIRUS reactor was used to produce the plutonium utilized in the Indian explosion of 1974."* The State Department replied that no U.S. heavy water was in the CIRUS by 1970 - an estimate that on examination was to prove incorrect.

> The United States sold 21 short tons of heavy water to India in 1956 under an Agreement which contained a "peaceful purpose only" guarantee. This quantity of heavy water met the moderating requirement of the CIRUS research reactor which began operation in July 1960 and achieved full power operation in 1963. Energy Research and Development Administration has indicated that heavy water degrades at a rate of about 10 percent per year which would indicate that, even without deliberate substitution, the U.S.-supplied heavy water would have been totally replaced by about 1970.
>
> India has a small heavy water production plant operated in conjunction with a fertilizer plant at Nangal. This plant, which was built with German assistance, began operating in 1962, and has a capacity of 15 short tons of heavy water per year. A heavy water reconcentration plant at Trombay began operating in 1965 and is capable of upgrading heavy water to 99.84 percent. Since the Nangal plant can produce in about one and a half years the requirements of the CIRUS reactor, it is believed that U.S.-origin heavy water was replaced from this source. The existence of excess heavy water in India during this period is borne out by the fact that it leased ten tons to Belgium.**

To the Senator's question, "If India advised the United States that the heavy water was not to be used, or was not in fact used, in the explosion program, in what ways was this verified?" Mr. McCloskey referred to Ambassador Kaul's statement of 1974 that "the Indian nuclear explosive had been produced by using one hundred percent Indian material, technology and personnel."***

---

* Ibid., p. 854.

** Ibid., p. 8

***Ibid., p. 855.

In the meantime, on March 2, 1976, some new faces had entered the picture. The Natural Resources Defense Council (NRDC) together with the Sierra Club and the Union of Concerned Scientists filed with the Nuclear Regulatory Commission a petition for leave to intervene in two separate license application proceedings for the export of slightly enriched uranium fuel to India: License No. XSNM-805 for the Edlow International Company to export 3055.20 kilograms of low-enriched special nuclear material and No. XSNM-845 for 18371.4 kilograms of the same.* This sort of petition had no legal precedent in the history of the Atomic Energy Commission, and in this first attempt some of the petitioners' arguments were a bit strained. For example, they reasoned that their members were affected by these nuclear export decisions, because the Atomic Energy Commission had an obligation to protect the health and safety of the public and that public was world-wide. Therefore not only members of the Indian public, but also a member of the Sierra Club travelling in India might be exposed to excessive radiation because of poor maintenance at the Tarapur power plants. However, this first naive approach to intervention by the trio of organizations was soon followed by petitions which displayed an increasingly sophisticated awareness of the weapons proliferation aspect of these export decisions and which founded their objections on the increasing danger of the spread of nuclear weapons.

The Nuclear Regulatory Commission requested written statements from the petitioners on the preliminary issues involved in this first intervention and scheduled an oral hearing for March 17th. The Department of State urgently petitioned on March 12th that the Commission consider each application separately and give priority to the license for XSNM-805, on the grounds of extreme

---

*March 25th Order by the Nuclear Regulatory Commission in the Matter of Edlow International Company as Agent for the Government of India, to Export Special Nuclear Material, Docket Nos. XSNM-805 and XSNM-845. Transcript, p. 1.

need in India. In an accompanying affidavit, Mr. Dixon B. Hoyle of the State Department reported that "unless slightly enriched uranium is received at the /Indian/ fabrication plant by March 31, 1976, operations at this plant will be disrupted...even a marginal delay beyond the March 31st date will entail considerable hardship and irreparable interruption in the re-fueling cycle which would cause serious damage to the Tarapur project as a whole."*

Apparently the information furnished by the Indian Atomic Energy Commission to the State Department had been incorrect or incomplete. For on the day before the hearing, Mr. Hoyle filed a second affidavit informing the Commission that he may have overstated the impact of further delay. However, during the oral hearing on March 17, Mr. Irwin Goldbloom of the Department of Justice who appeared for the Department of State, again insisted that time was of the essence, and the Commission as well as the State Department therefore pressed the Indian AEC for the exact facts about the dire need for fuel for the Tarapur. March 31st, after all, was just around the corner, and the State Department was concerned that the U.S. government not damage further its reputation as a reliable supplier.**

By March 25th, it appeared that there was no reason for urgency.***

---

* Ibid., p.3

** The first damage had been done by the U. S. government's announcement of a uranium shortage and the rewriting of contracts in 1973 for providing enriched uranium to foreign countries. See Monograph #2.

***NRC March 25 Order op.cit. p. 4:

"-- India currently has on hand at the fabrication facility 41,000 kgs or uranium, including 5,000 kgs of scrap and 30 finished fuel elements.

-- The 41,000 kg of uranium on hand at the fabrication facility will allow the preparation of approximately 260 fuel elements.

-- Each reloading of one of the Tarapur reactors nominally requires 70 fuel elements. According to Mr. Hoyle's March 18 affidavit, the actual number of fuel elements requiring replacement at a single previous reloading has been as high as 118.

-- Reloading of each reactor is nominally expected to occur at intervals of about 10-12 months.

-- On the basis of the parameters the State Department has supplied and existing Indian uranium supplies, the following schedule of reactor fuel availability may be derived.

The Commission indeed expressed surprise that the State Department had even been considering shipping the material by air. It concluded that "it is reasonable to take July 1, 1977, as the earliest date on which the uranium now on hand in India might not be sufficient to refuel the Tarapur reactors."* Furthermore, the Commission noted that "The Agreement addresses the supply of fuel for the reactor, not of feedstock for the fabrication plant....That supply at the present time and on our present understanding belies any claim of imminent shortage or, correspondingly, urgency."** The Commission therefore ordered both petitions to be considered together and requested final written submissions on March 26th, with a hearing ultimately scheduled for July.

	Fuel Elements Remaining After Refueling	
Refueling Date	Assumed Nominal Use Per Refueling (70)	Assumed Maximum Use Per Refueling (118)
Current Supply	260	260
July/August 1976	190	142
January 1977	120	24
June/July 1977	50	(94) (deficit)

Thus, it is reasonable to take July 1, 1977 as the earliest date on which the uranium now on hand in India might not be sufficient to refuel the Tarapur reactors."

*Ibid.

**Ibid., pp. 7-8.

Delays and inaccuracy in the information supplied to the State Department and to ERDA by the Indian Department of Atomic Energy may have accounted for some of the State Department's failure to answer the petitioners' questioners directly in July.

However, another complication arose from the fact that answers to the questions required a prolonged and massive search of files that in government circles can only be regarded as ancient history. From the point of view of busy government officials, it is an agony to have to put aside urgent questions of the day, which are demanding immediate answer, in order to look for background negotiations to contracts that were written twenty years ago or to answer questions that never arose at the time the contracts were made. Some of these files were located in response to Senator Ribicoff's questions.

But clarity was not served by the various attempts of spokesmen for the State Department, ERDA and the NRC to justify earlier U.S. policies toward India which in the light of more recent history appear to have been incautious. It is always difficult to admit a mistake, but surely in the end better and at least more dignified than the contortions that resulted from the explanations about U.S. heavy water in CIRUS.

The first position taken by the U.S. government officials was that no U.S. heavy water was in the reactor while it was producing plutonium. Ambassador T. N. Kaul of India, as we have seen, stated in ringingly exact numerical terms that the explosive was made using "100% Indian material". We went along with that. In fact, the State Department spokesman in his response to Senator Ribicoff said the same. "No effort was made to verify this statement, since it would have been impossible to determine the origin of the heavy water actually in CIRUS at the time the plutonium used in the nuclear device had been produced.*

*U.S. Senate Hearing on S-1439, op.cit., p.855

Of course it is possible that the Ambassador meant that the natural uranium in the reactor was exclusively Indian, not that the heavy water which only moderated the neutron bombardment but was not itself transmuted into the explosive material used inside the bomb was Indian. That claim would be simply irrelevant, since the issue was the use of U.S. supplied heavy water as a moderator. This interpretation would limit the Indian denial only to the transmuted material inside the bomb. But the Ambassador also said that "100% Indian personnel"* were used in making the explosive, and by this he certainly did not mean merely that there were only Indian personnel inside the bomb. Heavy water, like the personnel, was employed in making the bomb material and, like the personnel, it did not wind up inside the bomb. Heavy water is neither fissile (like U-235) nor a fertile source of fissile material (like U-238). However, it was an essential material used in producing the fissile plutonium for the Indian explosive. And it was not "100% Indian."

Still another twisting of the normal logic was offered in order to reach the conclusion that Ambassador Kaul really did not imply that the materials used as a moderator were not American when he indicated that all the materials used were "100% Indian." Ambassador Kaul was addressing the question as to whether the materials, facilities, etc., used were Canadian. When he said they were "100% Indian," he meant merely that they were not Canadian. Or at least he was "focusing" on Canada. That at any rate seems to be the NRC staff's reading of available evidence and it led them in advance even of the hearings on the subject, to the conclusion that there was "no representation focused on the use of heavy water supplied

---

*"We did not use or divert Canadian material; in fact, we used 100 percent Indian material, Indian technology and Indian personnel." Letter of June 29 to Mr. Benjamin Huberman, NRC, from Myron Kratzer, Hearing on S. 1439, JCAE, *op. cit.*, p. 18.

by the U.S."* But the question of subjective focus is strictly irrelevant in reading the evidence as to the straightforward meaning of Ambassador Kaul's language. If he meant simply that the material was not Canadian he could have said exactly that. What he did say was that it was 100% Indian, which means that it was 0% American, 0% Italian, 0% German, as well. The NRC staff concluded, along with the State Department, that there has been no evidence that the Indian Government misled the United States Government.**

On the contrary, whatever else is true in this tortured set of readings, it is apparent that the U.S. Government, willingly or unwillingly, was misled, whatever the intent of the Indian Government. And it elsewhere acknowledged that "Our earlier conclusion in this regard was the result of misinterpretation of Indian remarks.*** As recently as June 2, 1976 the State Department spokesman**** assured Senator Ribicoff that no U.S. heavy water was in the CIRUS reactor when it was producing plutonium and the spokesman was clearly talking about the U.S., not Canada. Moreover, the sole source of information on the status of the heavy water in the CIRUS was the Indian Government. In fact, according to Nelson Sievering, Jr., Assistant Administrator for International Affairs, ERDA, "After careful review of this matter, the Atomic

---

* U.S. Nuclear Regulatory Commission, "Staff Comments on Proposed Export of Special Nuclear Material to India (License No. XSNM-845)", July 8, 1976. Typescript, p.7.

** Ibid.

*** Letter from Kratzer to Huberman, op.cit., p. 18.

****See p. 3- 144 of this Monograph.

Energy Commission decided that it would be appropriate to reconfirm with the Indian Government that the Ambassador's statement meant that no U.S. supplied heavy water was used for this program."* After receiving from Dr. Sethna a confirmation that only "100% Indian material" was used, the Chairman of the AEC "Dr. Ray concluded that further correspondence on the question of whether U.S. supplied heavy water had been used in connection with production of the subject plutonium was unnecessary."** If the Ambassador's statement was relevant, it was false. Yet it was reiterated by the State Department spokesman, based of course on the technical information supplied to him.

That technical information was unfortunately very faulty. It purported to show that the CIRUS was empty of all U.S. heavy water, because (1) the initial U.S. load of heavy water had leaked or degraded at the rate of 10 percent a year and (2) ten years had passed, with the result that none was left. However, the first point was factually in error: The heavy water is used as moderator in the Canadian NRX type of research reactor, not as coolant, and has no substantial rate of degradation. Many documents in the AEC files support a degradation rate of less than one percent a year. The second point is more embarrassing. It defies not the facts, but the laws of arithmetic and physics. Even if the heavy water then in the reactor degraded at 10 percent per year, and each year the

---

*Letter to Mr. George Murphy, Executive Director, Joint Committee on Atomic Energy, Congress of the United States from Nelson F. Sievering, Jr., June 17, 1976. Hearing on S. 1439, JAEC, op. cit., p. 13.

**Ibid.

percentage lost was replaced by purely Indian heavy water, there would still be after 10 years 35% of the original U.S. water. At the end of the first year 90% of the American water would be left; at the end of the second year 90% of that 90 (that is, 81%) would remain, and at the end of the third year 90% of the 81% (which is 73%), and so on, until at the end of the tenth year 35% remains.

Presumably the Indian water added each year would be leaking or degrading also. But as one witness before Congress testified, the State Department's view of the matter suggests that molecules in India don't obey the laws of physics, but a caste system in which our molecules were untouchable by theirs, and only ours leaked or degraded.*

Both the facts about the plausible degradation percentage and the logical consequences of any specific degradation were botched in these first explanations. When this became apparent, the State Department retreated to the view that while some of the heavy water was undoubtedly ours, (1) it probably wasn't much, because they had a heavy water plant whose cumulative production was large compared to the 21 tons we supplied under the CIRUS contract, and (2) even if they did use our heavy water, they needn't have; they could have used their own.

On the first point, not much needs to be said. (The lady was only, so to speak, slightly pregnant because the baby was so small). It is worth noting, however, that the Indians later leased heavy water from us in sizeable amounts for the Zerlina reactor, namely 15 tons, under a peaceful use constraint and indeed under safeguards, and they had our heavy water transferred by way of Canada for the RAPP I reactor in the amount of 130 tons. The

---

*Statement of Albert Wohlstetter, June 16, 1976 in the U.S. Congress, House Committee on International Relations, Extension of the Export Administration Act of 1969, USGPO, 1976.

last arrangement was made in late 1971 and the Indians needed urgent help from the Soviets, who sent 50 tons. All of this suggests that the Indians were not producing up to the theoretical limits in their own heavy water plant;* which, alas, was constructed also with American help in design, and with the services of Vitro International, an American corporation. In any case, they could not meet their heavy water needs themselves. We have already documented from Indian sources the fact that a shortage of heavy water has been a principal constraint on the Indian program for natural uranium reactors, even though the United States has been the main source for the heavy water the Indians have used.

One may doubt whether in fact the Indians were only slightly pregnant with our heavy water. But the main point, of course, is that pregnancy is a yes-no matter. Our agreement meant that none of the material can be used for nuclear explosives, not that some or only a little can be so used.

The second point--that even if the Indians used our heavy water, they need not have--is the most dangerous of the apologetics attempted so far. For this suggests that there is no point in our safeguarding or constraining to peaceful-use-only any facility or material or technology in a country which conceivably could get the equivalent from someplace else. The Indians can produce plutonium in their CIRUS and even more in the super-CIRUS soon to be completed. Shall we say therefore that since they

*State Department answers to questions about actual production figures on heavy water at Nangal refer only to "production capacity." Either there has been no Indian accounting, or the Indians have not supplied the figures. Early planned capacity was six tons a year. State Department answers refer to 14 to 15 tons annually.

can get bombs from their other facilities, it is quite all right for them to use our facilities also for producing bombs?

In fact, the State Department's answers in Hearings and in the responses to specific questions raised by the NRC and the NRDC suggested that the restraints or concerns about our low enriched uranium fuel in Tarapur were really unnecessary because the Indians have alternative ways of getting fissile material. That would mean that the safest way for us to furnish nuclear cooperation constrained to peaceful uses only is to encourage governments to get production reactors that are <u>not</u> under a peaceful use constraint at all. If a country can make a bomb easily without using the equipment or materials we supply, our own material would be safe. Of course, the point of it all is to discourage bomb manufacture and it is only this point that seems constantly to escape our grasp.

Finally, various government officials have claimed that the Indians did not explicitly say that they had not used our heavy water. We misunderstood. Very well then. That changes things. Now we understand. The Indians violated the peaceful-use constraint implicit or explicit in all our agreements on cooperation.* Their behavior would seem to call for a drastic revision in our agreement for cooperation of the kind announced by the President on October 28, 1976. It would condition U.S. cooperation more explicitly on the recipient's agreeing clearly not to obtain nuclear explosives or even to obtain highly concentrated fissile material which can be quickly made into explosives. The exchange of letters between Dr. Ray and Dr. Sethna in September, 1974 does not accomplish this purpose.

*. Other supplier nations know this and believe that the U.S. failure to respond means that the U.S. is not serious.

INDIA AND THE "PEACEFUL USE" CONSTRAINT

U. S. policy on the peaceful use constraint has been far from lucid. However, common sense suggests several points.

When we say that facilities or materials or technology that we transfer are constrained to be used solely for peaceful purposes, this excludes any use which has a plainly immediate military potential. And the most obvious military function excluded is the development of a capability to detonate nuclear explosives.

The development of a nuclear explosive using our transfers therefore violates the plain meaning of our contracts for nuclear transfers or our agreements on nuclear cooperation. It makes no difference that

a. the transferee never accepted explicitly that the agreement excluded all nuclear explosives, or the development of a capability for such, nor that

b. we may not have made explicit at the time of the agreement that nuclear explosives are excluded, nor that

c. the transferee at some later stage explicitly denied that nuclear explosives inevitably had a possible military use, nor that

d. the agreement on limiting the transfer to peaceful uses only was not accompanied by safeguards.

It makes no difference, that is, so far as establishing the fact that the recipient of our nuclear assistance has evaded the intent of that assistance, and therefore provided a warrant for a cutoff of further assistance or even more severe sanctions. It certainly offers no excuse for failing to condition further assistance on tight conditions that would prevent a repetition.

We could add the further point that it makes no difference whatsoever to the intent of our policy whether the transfer was a gift, a sale, or a lease, or whether it was a facility we were transferring, or simply materials, although the Indians went through the most elaborate maneuvers to draw such distinctions.

The plain truth is that the Indians wanted to avoid any constraint on nuclear transfers which would prevent them from converting the transfer to whatever purpose they pleased, and failing in that, they wanted to avoid having any safeguards to monitor whether or not the conditions of the transfer were violated. They fought the language specifying limitations to peaceful use only, entering exceptions wherever they could get away with it

They fought any admission that a nuclear explosive inevitably had a military use. When it became clearthat we were going to insist on a peaceful use constraint on our heavy water in the CIRUS reactor, they fought successfully against the provision of safeguards to monitor the peaceful use constraint. When it became clear that there were going to be safeguards on the heavy water we were to provide for the Zerlina research reactor , they successfully arranged to lease rather than to buy our heavy water, on the grounds that this would preserve the principle that Indian material should not be safeguarded. In the case of the Tarapur reactor, where they were actually buying the low enriched uranium, they fought to preserve at least their position that only the materials were subject to safeguards, and if the Tarapur were to use other materials, the facility itself would not be subject to safeguards. On their view only the coincidence that Tarapur was to use our materials exclusively made it appear to be subject to safeguards.

In short, in dozen of ways, in their bickering over every word to provide loopholes in our agreement contracts, the Indians demonstrated that they wanted to preserve their option to do whatever they wanted with the material, whether for civilian or military purposes. The details of such negotiations only illustrated in concrete terms the position they were stating in principle in international forums, such as those that were debating the setting up of an international atomic energy agency. Not only the safeguards that monitor the limitation, but the limitation itself is a violation of their sovereign independence and a vestige of colonialism. Any attempt now to apply sanctions is attacked in the same terms.

U.S. policy on the other hand after the Indian explosion seems to have been directed mainly at saying that a fait accompli isn't really a fact at all, even though it might look very much like one. Take, for example, the answer of a representative of ERDA's General Counsel Office to Senator Case on June 22 before the Joint Committee on Atomic Energy. Dr. Seamans, Administrator of ERDA, had indicated that some of our heavy water was in the CIRUS reactor when it was producting the plutonium used in the Indian nuclear explosive detonated in 1974. "Does this violate our peaceful uses only constraint?" asked Senator Case. Dr. Seamans deferred to the counselor who noted that our contract with the Indians for heavy water did provide that the heavy water would be used only in peaceful applications, but that it was "not, as you know, an agreement for cooperation . . . under which they not only make a peaceful uses assurance and specifically exclude nuclear weapons but also accept IAEA safeguards."*

But this is no answer at all. The question is whether the Indians violated the constraint, not whether we had an inspection system which would detect it. In fact, the Indians made a nuclear explosive out of the plutonium produced in a reactor moderated by U.S. heavy water transferred under a contract that explicitly excluded any military use, and we have many times since 1966 reiterated that any nuclear explosive has a military use. In short they violated the constraint. And this makes only more poignant the fact that we had not insisted on a policing of the agreement. That was a bad mistake, proven by the act of violation. Nevertheless, the counselor's tentative response might suggest that thefts are not larceny, if no arrangements have been made for police to catch the thief.

Let us hope that U.S. policy on the peaceful use constraint in the future may be guided by the lessons of the Indian experience.

*Hearing on S-1439, JCAE, op.cit., p.13.

POLICY IMPLICATIONS OF THE INDIAN-CANADIAN-U.S. EXPERIENCE IN NUCLEAR COOPERATION

This case history has implications (a) for decisions on future U.S. cooperation with India itself and these are of course the policy choices most directly illuminated; (b) for the choice of policies for stopping the spread of nuclear weapons to other countries as well as India, and this more general application of the U.S.-Indian experience is perhaps even more important.

Some causal connection actually exists between the two, between the policy we adopt toward India in the future and the influence we can exercise on other countries. Our policy towards India sends a message to other countries that may be more persuasive than declaratory statements about the rewards and penalties of actions that might violate the letter or spirit of our anti-proliferation policy. But even apart from this direct effect of our Indian policy on our policies elsewhere, it is apparent that the sequence of events leading up to the Indian explosion in May, 1974, had a very widespread and immediately recognized significance as a major challenge to policies that had been directed at transferring nuclear technology for peaceful uses only and at the same time discouraging or preventing its military application. In the three years since the Indian explosion international awareness of this challenge has deepened. It has not, as some expected, dissipated. In fact, in spite of all that has been written about the Indian nuclear program, the implications of its history are not yet widely understood. Yet they are directly relevant for much of the current debate on nuclear export policy.

(a) On the points of general importance.*

1. Stopping drifting governments versus stopping governments which are committed from the start.

It is frequently argued today that there is no point in constraining exports of plutonium separation plants or uranium enrichment facilities or even in limiting exports of plutonium or highly enriched uranium themselves. There is no point, and it may even be bad, the argument runs, because almost any country committed to getting nuclear weapons can get them by itself,** for example by designing and building a production reactor. After such a facility (say, a simplified version of the Brookhaven Graphite Research Reactor taking four or five years to build and using natural uranium) is fully operational, it will produce plutonium in the spent fuel that might yield material for one or two bombs a year.*** Such

---

* I draw here on recent drafts of Albert Wohlstetter's Monograph #1, which is itself based on this and several other country studies.

**See for example the views of Peter Hermes, State Secretary of the Foreign Ministry, West Germany, and Hans-Hilger Haunschild, State Secretary of the Research and Technology Ministry, as summarized in Nucleonics Week, Feb. 10, 1977, p.9. "Bonn hopes that Washington will see the /Brazil-German/ deal in a different light after a more detailed study of its safeguards, which as German government officials are quick to emphasize, go beyond those of the non-proliferation treaty. German philosophy is that a country really wanting the nuclear bomb will get it anyway. The Bonn belief is that it is better to extend cooperation at a time when it is still possible to persuade the recipient country to accept international controls rather than turn down the threshold country's request for technology, letting it reach its nuclear goals through its own development work, without IAEA inspections. As it is, 'the /German-supplied/ Brazilian nuclear facilities will be fully subject to IAEA controls'". See also C. Starr, W. Haefele, E. Zebroski, draft paper on "Nuclear Power and Weapons Proliferation," March 1976; E. Zebroski, contribution to Panel on "U.S. Nuclear Policy and International Security", Dec. 7, 1976; California Seminar on Arms Control and Foreign Policy; and a 58-page recent Westinghouse study cited by Nucleonics Week, March 31, 1977, as showing that there are "multiple avenues" other than by way of LWR plutonium that can be followed by a "*determined* non-nuclear weapons state." (italics added).

*** John Lamarsh, "Construction of Plutonium-Producing Reactors by Small and/or Developing Nations", April 30, 1976, reproduced by the Library of Congress, Congressional Research Service, June 4, 1976.

a country could also design and build a reprocessing facility for extracting plutonium from the irradiated fuel rods.* If we do not export facilities for producing such highly concentrated fissile materials or the materials themselves to such countries who are intent on getting nuclear weapons, we will compel them, it is said, to do it on their own. It would be better for the United States to supply these under safeguards.

This line of reasoning, which is sometimes buttressed by a reference to the Indian example, has many weaknesses. In fact, an examination of the Indian experience reveals a key flaw in the argument. It is essential to consider not merely governments that have made up their minds to get nuclear weapons and to get them perhaps at any cost. That list is likely to be very small indeed at the present time, as it has been in the past. More important is the much larger list of governments that at any given time have not made up their minds at all, or that have not even seriously considered a nuclear weapons program, or that have considered it and quite sincerely rejected it.

That larger list is the one that policy must principally address: the countries that can drift towards a military capability without trying to, and without any intention of arriving at it; and yet may adopt a civilian program that ultimately places them within days of acquiring material for nuclear explosives. The Indian experience illuminates that process of drifting towards a bomb. Canadian and U.S. help -- transfers of facilities, equipment and material, advisory scientific and engineering services, training of Indian personnel, financial subsidies and loans -- formed a major ingredient of the Indian program which was shortening critical time to make an explosive. And this help was given before and after the Indians revealed a strong interest in nuclear explosives. It continued after the time when Indian officials were

*John Lamarsh, "On the Extraction of Plutonium from Reactor Fuel by Small and/or Developing Nations", July 19, 1976. Reproduced by the Library of Congress, Congressional Research Service, Oct. 14, 1976.

formally and informally issuing statements that the Indian nuclear program had shortened the time remaining before they could get an explosive, and while the time announced was growing shorter and shorter. Bhabha and Nehru announced before the Phoenix went into operation that they would need only 18 months after the decision. Then later as they drifted closer they announced the interval as only six months.

During this period both the U.S. and Canada made public announcements indicating that "exclusively peaceful applications" excluded by definition explosives of any kind, and the Canadians made many private reminders of this point. However, in advance of the actual Indian explosion, neither Canada nor the United States insisted that the Indians themselves publicly agree with them and still less did either government demand that India eschew forms of nuclear research and nuclear electric power activity that would provide them with stocks of plutonium or simple compounds of it, and thus bring them closer to a nuclear explosive. Nor did the U.S. Or Canada ever explicitly say that stocking plutonium was illegitimate.

Canada waited until after the explosion to insist on India's dis-avowal of a nuclear explosive program and it was only in 1976 that both governments indicated that civilian activities involving stocks of plutonium might themselves have to be banned. The latter course of action finally faces up to the question of stopping a drift towards the bomb by countries not yet committed.

2. Current pure intentions are not enough.

A point closely related to the preceding one is also clearly confirmed by the Indian experience: The fact that a government receiving nuclear transfers has the purest of motives at the time of receipt, that it intends to use this aid solely for purposes of advancing civilian electric power, and that it abhors nuclear weapons, offers no assurance that it will not change its mind, and provides no warrant therefore for favored treatment in granting aid which will shorten the time to make an explosive. Since such aid makes it technically easier and cheaper to get nuclear weapons and means that the progress towards nuclear weapons can be more ambiguous, or concealed, and politically less risky, it also facilitates a change in intention responding to new external or internal pressures. Only a policy that restricts the forms of nuclear energy (in research or in production of nuclear power) to those that exclude national control of highly concentrated fissile material can deal with future intentions to make nuclear weapons and make it less likely that present good intentions will change.

This particular lesson is relevant today to the situation of several countries (Japan, Sweden, West Germany) whose current intentions are on all the evidence exemplary, but whose programs of nuclear cooperation with us and other suppliers involve an accumulation of plutonium and highly enriched uranium.

3. "Safeguards" are necessary but not sufficient.

Bilateral and international safeguard systems are essentially arrangements for accounting and inspection. They are intended to deter bomb manufacture by assuring early warning and permitting timely counteraction.*

---

*Laws and Regulations Governing Nuclear Exports and Domestic and International Nuclear Safeguards, Message from the President of the United States, May 6, 1975, USGPO, Washington, D.C., 1975, p.35; General Starbird, Assistant Administrator for National Security, ERDA, "Statement before the Senate Committee on Government Operations", January 29, 1976, Hearing on S-1439, op.cit., p.408; IAEA INFCIRC / 153 (1971) and B. Sanders and R. Rometsch, "Safeguards against Use of Nuclear Materials for Weapons", Nuclear Engineering International, September, 1975, p.683; and chapter 3 of Moving Towards Life in a Nuclear Armed Crowd? Report to the Arms Control and Disarmament Agency by Wohlstetter, et al, of Pan Heuristics, Los Angeles, California, April, 1976, p.72.

The Indians resisted safeguards with very substantial, though partial success. Some of their facilities are not or will not be safeguarded at all, even though they involve technology that is at least directly descended from some Canadian and U.S. imports: for example, the heavy water reactors under construction at Madras. Other facilities given them by Canada and materials given them by the U.S., though restricted to peaceful uses, were unsafeguarded: so CIRUS and the U.S. heavy water used in it. Nonetheless even if this unfortunate laxity had been avoided, safeguards would not have been effective in fulfilling the purpose of providing timely warning, if the Indians had been permitted to separate plutonium, to fabricate it into mixed plutonium uranium oxide fuel and in the course of these activities, to stock significant quantities of plutonium or simple compounds of it under their control for use either in electric power or research. To prevent the sudden manufacture of a nuclear explosive without warning requires not only safeguards on essentially all research and power facilities that could contribute substantially to the eventual accumulation of fissile material, but restrictions on the accumulation itself.

4. Ambiguities can vitiate policy.

The Indian agreements for cooperation with the United States were loaded with ambiguities, unilateral understandings and formulations compromised with a view towards speeding the conclusion of the agreement itself. These defects, however, reduced the effectiveness of any deterrent value of the agreements and made it less likely that we would take any strong action in response to a violation of their common sense meaning. The Indian experience makes clear that only agreements that plainly stipulate the meaning of the essentials are likely to survive intact in the face of the changing purposes of the government involved. Nothing else will discourage violation or make sanctions against violation probable.

5. <u>Policy towards countries that make nuclear explosives in spite of an agreement to restrict nuclear activities to peaceful uses only</u>.

The Indians used a facility given by Canada and some of our heavy water to make and test a nuclear explosive. They did this in both cases under a peaceful uses only agreement, and the State Department makes clear that our agreements had always intended to exclude such a development.* Nonetheless we are faced with the fact that, whatever our or their good intentions, they have produced at least one nuclear explosive. What should be our course of action?

On one side it can be argued that the damage is done. India has carried through the program, and we might just as well, as in the case of the French, acknowledge the fact and treat India as a full-fledged member of the club, along with the preceding five members. Or we might reduce our embarrassment somewhat by accepting India's distinction between peaceful and military explosives and, to preserve the fiction, provide them, so to speak, with only an associate membership in the club. If we don't, India can go ahead with its own program, having advanced so far, and moreover, as a potential supplier of nuclear technology, India could proceed to help other countries to follow in her footsteps with a nuclear explosive program. There is no point simply in punishing India, and encouraging her to be irresponsible.

On the other hand, such arguments, though tempting, have disturbing implications for future aspirants to nuclear weapons. For what it will suggest to them is that we will oppose their getting nuclear weapons and even threaten dire consequences if they do, but should they be successful in ignoring our opposition and our threats, we will never execute the threats,

---

*Robert J. McCloskey, U.S. Senate Committee on Government Operations, <u>Hearings on S-1439</u>, <u>op.cit</u>. June 16, 1976, p.811.

and never impose any sanctions, but only reward them with membership or associate membership in the club. If in addition we permit civilian activities that bring countries close to manufacture of nuclear explosives in any case, then the interval of unpleasant opposition from us before we reward them will be gratefully short. The truth is that we oversimplify when we say that "the damage is done" as soon as a country explodes a nuclear device. Much more damage will be done if we do nothing to make the country regret its action. This is especially true if there has been a violation of the sense of an agreement. But even for those few countries that have never disavowed an interest in nuclear bombs, we should make clear in advance that in case they do, success will not be met by a welcoming committee of the club. It will cost them something.

6. <u>Policy towards countries that do not disavow intentions to make nuclear explosives, "peaceful" or otherwise</u>. There are about a half dozen countries of importance that have refused to ratify the NPT or to make a separate statement that they will forego even "peaceful" nuclear explosives (besides India, these are Pakistan, Argentina, Brazil, Israel, Egypt). The Indian case illustrates the dangers of continuing nuclear cooperation with such countries and remaining content with unilateral statements to the effect that such nuclear cooperation is premised on the recipient's not making nuclear explosives at all or at least not making them with the aid furnished in a specific U.S. nuclear agreement. I believe that U.S. policy should refuse nuclear cooperation unless these countries give up nuclear explosives altogether, and not just nuclear explosives made using our help. This means no slightly enriched uranium, no heavy water, no reactor sales, no advisory services, no nuclear transfers of any sort.

7. Nuclear guarantees, conventional military assistance and vertical proliferation.

Indian military concern centered primarily on China rather than Pakistan, and in fact as distinct from rhetoric, not at all on a threat from the two superpowers. Indian arguments in international forums about superpower disarmament were in good part a way of justifying their own armament and nuclear explosive program. The Indians were interested in help from the superpowers against China, and superpower disarmament was rather irrelevant or inconsistent with that goal. Although they have made constant reference to the evils of vertical proliferation from the mid-sixties on, the evidence suggests that this was merely a debating point. It is moreover doubtful that substantial superpower disarmament would in general influence a country not to undertake a nuclear weapons program, if it is concerned about nuclear threats from other sources.

The Indian experience confirms that countries that by choice or circumstance stand outside alliance systems are particularly liable to decide to make nuclear explosives, if it is easy for them to do so and if the international environment changes adversely. The Indian cautious attempts to get nuclear guarantees jointly or separately from the U.S. and the Soviet Union yielded nothing very substantial, and U.S. conventional military assistance was withdrawn just about the time that Indian concern about the Chinese nuclear explosive program was most acute. A policy to discourage nuclear proliferation has to deal with legitimate or perceived military challenges, both direct and indirect, to the countries concerned.

(b) On policy specifically towards India.

1. <u>Develop policies for the new Indian administration simultaneously with a policy for Pakistan.</u>

The new administration in India has begun with a rejection of nuclear weapons and an expression of doubt about the usefulness of "peaceful" nuclear explosives for India. Morarji Desai seems likely to be sceptical of the sort of technocratic idyll that has animated the nuclear energy program in India in general and that in particular might give some shred of plausibility to such dubious gadgetry as Plowshare*. The nuclear bureaucracy in India has been most closely linked with the Congress Party, with Nehru and with Mrs. Gandhi. This is a particularly opportune time, then, to induce a revision in Indian thinking and to move her away from nuclear explosives.

However, there are obstacles other than the Indian nuclear bureaucracy. First of all, our own nuclear industry and bureaucracy have fostered many of the Indian positions on nuclear energy and rationalised them for the American Congress. A change in policy in India presupposes a very clear cut change in American policy at the working level, as well as at the top.

Second, India has some legitimate defense concerns and insofar as she has any continuing worry about a Chinese nuclear threat, she may require some sort of assurance of help. For the United States to provide this assurance may be hard to manage.

Third, India nonetheless has an interest in seeing to it that Pakistan, an irredentist power with respect to parts of India, and an adversary with whom India has been engaged several times in the short history of Indian

*Morarji Desai has been on record for some time against nuclear weapons for India. He is quoted as saying "'We can drive out any aggressor even without the bomb.' 'If China were to throw an atomic bomb on the Indian border, she would create an impenetrable barrier for herself.'" Hari Ram Gupta, <u>India-Pakistan War</u>, <u>op</u>.<u>cit</u>., Vol. II, p.100. In his first public press conference since his election as Prime Minister he also expressed doubt as to whether a nuclear explosive program would be useful for India and advised returning to "cottage industry". <u>Newsweek,</u> April 4, 1977, p.36.

independence, does not itself get nuclear weapons. There is no doubt that Pakistan has been powerfully moved to get nuclear explosives by India's own explosive program, and that Pakistan's desire to improve its conventional forces is motivated mainly by its adversary relation with India.

All of this suggests that it is essential to try to use a formal abandonment of India's nuclear explosive program as a lever to get a similar commitment from Pakistan about nuclear explosives: and vice versa. And in a similar way, it is important to try to arrange for the simultaneous abandonment by Pakistan of its plans for a reprocessing plant and for the abandonment or indefinite deferral by India of its plans to reprocess.

2. We should assure India of fissile material equivalent in amount to that which she might derive from reprocessing spent fuel. This equivalent would be in the form of natural or slightly enriched uranium.

3. We should offer to take back India's spent uranium fuel, and to lease rather than sell her slightly enriched uranium fuel rods in the future.

4. The plutonium content of the spent fuel has an uncertain value which will depend on the relative costs of deriving fissile material from spent fuel, compared to the costs of freshly mined uranium. It may have a negative value. We should offer India, if she likes, an equity interest in any use of her spent fuel to extract fissile material. That is, if in the future it is profitable to extract plutonium from spent fuel, we should give India a credit for the positive value of the plutonium as an offset for the cost of the slightly enriched uranium which we supply as a substitute. If this risky venture of reprocessing is nevertheless undertaken and there are losses, India, with an equity stake, would have a debit to add to the price

of slightly enriched uranium. India should not be obliged to take the equity risk in reprocessing, but making it clear that she has the opportunity will make it clear also that it is highly uncertain that plutonium embodied in spent fuel has a positive value.

5. If India does not explicitly disavow a nuclear explosive program, and if she does not accept full fuel cycle safeguards, we should stop nuclear cooperation with India.

6. If India does disavow nuclear explosives and accepts full fuel cycle safeguards, we should supply her with slightly enriched uranium and heavy water only if she also agrees not to accumulate plutonium or highly enriched uranium, and only if she agrees not to maintain facilities that could quickly provide stockpiles of such highly concentrated fissile material. A more restricted immediate policy initiative would ask India to defer any further contracting in to a program yielding stocks of highly concentrated fissile material, while we negotiate with her to provide equitable less dangerous substitutes for the highly concentrated fissile material or the facilities yielding it.

Addendum A

PRESS CONFERENCE WITH DR. BHABBA AS REPORTED IN THE BOMBAY TIMES OF INDIA OF AUGUST 5, 1956 ON APSARA

"The entire control system of the reactor that was put into operation on Saturday was designed and built by the Reactor Control Division under Mr. A. S. Rao, while the engineering drawings for the reactor were prepared by the Engineering Division under Mr. N. B. Prased, which division also supervised its construction.

"After the decision to build the reactor was taken by the Commission last year, different designs for the shape of the pool and experimental facilities were discussed by a committee consisting of Mr. Prased, Dr. Ramanna, Mr. Rao and Dr. Singhwi.

"Two designs for the pool were considered, one in which the reactor moves horizontally in a rectangular tank and the other in which it moves in a vertical cylindrical well. The possibility of combining the two systems were also considered. It was finally decided to adopt the design with horizontal motion as this provided the diverse experimental facilities needed for this reactor.

"The reactor, which is housed in a hall 100 feet long, 50 feet wide and 70 feet high, consists of a rectangular concrete tank 28 feet x 10 feet and 28 feet deep, with massive concrete walls 8½ feet thick. The reactor is immersed in this pool of water, hence the description "swimming pool type."

"The core of the reactor is approximately a cube of two feet wide, which is suspended by a rigid frame from a trolley above, which moves on rails mounted on the sides of the pool. The core consists of from 25 to 30 fuel elements containing the fissile material, uranium 235, in the form of a sandwich. Each thin plate of uranium 235 aluminium alloy is sandwiched between two plates of aluminum. The fuel elements can be removed or placed in position by long aluminum rods operated from the trolley above.

"When in operation, the fuel elements generate heat through fission and are cooled by the water, which also acts as a 'moderator' for slowing down neutrons and provides the necessary protection to the personnel against radiation.

"The reactor is provided with a number of automatic safety devices, which shut it down in a fraction of a second if one of a number of danger signs appear. For example, it will shut down if the power fails, or excessive heat is generated, or certain instruments fail. The reactor is of a type described as inherently safe. Even if all the automatic controls were to fail and the reactor were to run away, the excessive generation of heat would convert the water into steam and the reactor would automatically shut down, because there would be no water left to slow down the neutrons.

"The fuel elements for the reactor have been provided by the United Kingdom under an agreement signed in October last year between the U.K. Atomic Energy Authority and the Department of Atomic Energy. The fuel elements were flown out in separate batches, a few at a time, and were stored in separate rooms for safety till they were loaded into the reactor.

"The completion of the reactor was delayed by several unexpected difficulties. The special paint with which the sides of the pool have to be painted was brought out on a cargo boat, which arrived two months late. Finally, when it reached Bombay harbour, the paint could not be unloaded for ten days because of congestion in the port and stormy weather. When the fuel elements came to be loaded in the reactor a few days ago, it was found that they would not fit because they had got slightly deformed in transit and had to be straightened. Considerable delays were also caused by the fact that the building to house the reactor was not ready on time. Despite all this, it has taken just about a year to design and build the reactor.

"The loading of the fuel elements started on Monday evening (July 30) and was continued till 1 a.m. The first trial run was started on Tuesday evening (July 31) with the loading of more uranium fuel elements. The neutron flux gradually rose, but by 7 a.m. on Wednesday morning (August 1) the reactor had not yet become critical. The scientists worked on Thursday (August 2) to change the disposition of the fuel elements and the control rods and the second run was started at 5 p.m. on Friday (August 3). The team worked right through the night, but by 10 a.m. no chain reaction had been achieved. A further rearrangement of the fuel elements was carried out and at 3:45 on Saturday (August 4) the reactor became critical. The scientists and engineers had worked without a break for nearly 24 hours."

Addendum B

SCIENTISTS ASSOCIATED WITH CONSTRUCTION OF APSARA

Dr. V. T. Athavale	Chemistry Division, DAE, an inorganic chemist.
Dr. Homi J. Bhabha	Secretary, Department of Atomic Energy, Director, Tata Institute of Fundamental Research, Bombay. Physicist and Cosmic ray expert.
Dr. K. C. Bora	Biology Division, DAE.
Prof. D. M. Bose	Head of the Bose Research Institute, Calcutta. Nuclear physicist.
Prof. S. N. Bose	One of India's outstanding theoretical physicists. Professor and head of the Department of Physics, University of Calcutta.
Prof. K. Chandrasekharan	Head of the Mathematics Section, Tata Institute of Fundamental Research.
Dr. Shanti D. Chatterjee	Physicist at Institute of Nuclear Physics, Calcutta University.
Dr. V. P. Duggal	Nuclear Physics Division, DAE.
Dr. A. R. Gopal-Ayengar	Member of the Biology Division of DAE. A cytologist interested in cancer research and leukemia.
Dr. K. S. Krishnan	Director, National Physical Laboratory, New Delhi. Very capable physicist.
Dr. V. R. Khanolkar	Director, Indian Cancer Research Center; and Chairman, Biological and Medical Advisory Committee, DAE. An outstanding pathologist in the fields of oncology and leprosy.
Dr. Ambuj Mukerji	Nuclear physicist.
Dr. B. D. Nag	Nuclear physicist.

S. Patuck	Administrative officer of the DAE.
Dr. D. Y. Phadke	Concerned with the accelerator program at the Tata Institute.
Dr. Prahm Prakash	Metallurgist with the DAE. Also head of the Department of Metallurgy, Indian Institute of Science, Bangalore.
M. B. Prased	Engineering Division, DAE.
M. B. Puerhi	With the Biology Division, DAE.
Dr. Raja Ramanna	With the Nuclear Physics Section, DAE. Also a member of the Nuclear Physics Section, Tata Institute of Fundamental Research.
Ayvagari S. Rao	Physicist and electrical engineer.
Professor Meghnad N. Saha	Nuclear Physicist, Head of the Institute of Nuclear Physics, Calcutta University.
Dr. Jagdish Shanker	Physical Chemist; chemist-in-charge of the Radio-Chemistry Division of DAE.
Dr. Kundan S. Singwi	Nuclear Physicist, head of theoretical physics research in the Theoretical Physics and applied Mathematics Division of DAE.
Dr. G. S. Tendoikar	Chemical engineer and fuel technologist associated with the Metallurgy Division of the DAE.
Dr. K. G. Vohra	Air Monitoring Division, DAE.
Dr. D. M. Wadia	Outstanding Indian geologist, Geological Advisor, DAE, and also Geological and Mineralogical Advisor to the Indian Ministry of Natural Resources and Scientific Research.

Addendum C

January 24, 1961

FROM : AMCONGEN, BOMBAY, INDIA

TO : The Department of State. Washington

SUBJECT: ATOMIC ENERGY: Opening of Canada- India Reactor and Other Facilities at Trombay; Status of Atomic Energy Program to Date

SUMMARY

At the Atomic Energy Establishment in Trombay, on January 16, 1961, before a gathering of internationally famed scientists and Atomic Energy Commission officials, Prime Minister NEHRU formally inaugurated five new installations including the Canada-India Reactor, a 40 MW, heavy-water moderated natural-uranium fueled research reactor. In his speech, the Prime Minister attacked those who question the economics of reactor development in India at this time. Dr. BHABHA, Chairman of the Indian AEC, also spoke, referring incidentally to an agreement to be signed with the USSR on natural-uranium and fast reactors.

Besides the Canada-India Reactor, the following facilities at Trombay were formally declared open:

ZERLINA, a small 100 watt research reactor

Uranium Plant and Fuel Element Fabrication Facility, to produce uranium rods for the two new reactors

Heavy Water Reprocessing Plant, to reconcentrate downgraded heavy water for re-use in the two reactors

ZERLINA went critical two days before the opening ceremony; the Reprocessing

Plant was completed the previous month; and at that time, Apsara, India's first research reactor—1 MW, ordinary-water moderated, enriched-uranium fueled--was re-started after closing down in August 1960 for repairs and improvements.

With the new installations, India has the beginnings of a comprehensive nuclear research and power program, including facilities for surveying and exploratory drilling for the uranium and thorium-bearing ores available in the country; for mining and extracting; for producing and reprocessing fuel elements and also heavy water; for engaging in effective nuclear research and for making radioactive isotopes for other research.

On January 16, 1961, at the Government of India Atomic Energy Establishment at Trombay, twenty-five miles from downtown Bombay, Prime Minister Jawaharlal Nehru formally inaugurated the Canada-India Reactor and certain other facilities. During the next two days, a Symposium on Nuclear Power was held at which speeches were made by the eminent scientists and Atomic Energy Commission officials who had come from abroad to attend the ceremonies (See Bombay despatch 436 of January 24, 1961). At the previous invitation of the Indian member, Dr. Homi J. Bhabha, Chairman of the Indian Department of Atomic Energy (DAE), the U.S. Scientific Advisory Committee also met in Bombay, on January 19 (See Bombay despatch 437 of January 24, 1961). The following day, a tour of the Atomic Energy Establishment was conducted. On January 21, the participants in the series of events departed on a 10-day Government tour of India (see Enclosure No. 1) that will include Republic Day festivities in New Delhi on January 26 and will not come to a conclusion until January 30.

Participants in the Week's Events--Some 48 foreign officials attended the various events of January 16-19. The United States delegation consisted of:

Dr. Robert E. WILSON,	Commissioner, AEC
Dr. I. I. RABI,	U.S. Representative, U.N. Scientific Advisory Committee
Dr. John A. HALL,	Assistant General Manager for International Activities, AEC
Dr. Robert A. CHARPIE,	Assistant Laboratory Director (Reactors), Oak Ridge National Laboratory

Other prominent figures attending were:

Mr. Gordon CHURCHILL,	M.P. Government Leader in House of Commons of Canada and Minister of Veterans Affairs
Mr. Herbert MORAN,	Director General of External Aid Office, Canada
Mr. J.L. GRAY,	President, Atomic Energy of Canada Limited
Dr. W. B. LEWIS,	Vice President, Atomic Energy of Canada Limited, and Canadian Representative, U.N. Scientific Advisory Committee
Mr. Sterling COLE,	Director-General, International Atomic Energy Commission
Mr. Philippe DE SEYNES,	Under Secretary, United Nations (representing Mr. Hammarskjold)
Prof. F. PERRIN,	High Commissioner, French Atomic Energy Commission
Dr. B. GOLDSCHMIDT,	French Representative, U.N. Scientific Advisory Committee
Sir Roger MAKINS,	Chairman, U.K. Atomic Energy Authority
Sir John COCKCROFT	Member, U.K. Atomic Energy Authority, & U.K. Representative, U.N. Scientific Advisory Committee

Prof. L. C. PRADO, Brazilian Representative, U.N. Scientific Advisory Committee

Representing the Bloc countries were the following:

U.S.S.R.	Dr. Oleg D. KAZACHKOVSKIY, Scientific Director, BR-5 Fast Reactor (replacing Prof. V.S. EMELYANOV, Chairman, State Committee of the Council of Ministers for the Peaceful Utilization of Atomic Energy)
Communist China	Mr. CHOU Pei Yuan, Chairman of Board of Directors of Society of Physics, member of the CPR Academy of Sciences
Hungary	Dr. Lenarct PAL, Deputy Director, Central Research Institute of Physics, Hungarian Academy of Sciences
Czechoslovakia	Ing. Dr. Vladimir SVAB, Director of the Institute for Nuclear Research

Other guests are listed in the first part of the booklet constituting Enclosure No. 1.

Opening Ceremonies--The ceremonies at Trombay were opened by Mr. Sri PRAKASA, Governor of Maharashtra. Mr. Churchill, Dr. Bhabha, and Prime Minister Nehru delivered addresses. Those of the first two are attached as enclosures No. 2 and 3. Nehru spoke without benefit of notes, and the text of his speech is not available at this time.

Dr. Bhabha described the development of the Atomic Energy Establishment since 1955 and the facilities which then were being formally inaugurated. In paying tribute to the nations besides Canada which had helped India in her atomic energy program, he mentioned the U.S. sale in March 1956 of 21 tons of heavy water now being used as the moderator in the Canada-India Reactor. He also stated, "In the course of the last year we have negotiated a broad agreement for cooperation in the peaceful uses of atomic energy, covering both natural uranium and fast power reactors, with the Soviet Union, which will be signed this year." Previously, at a press conference in Ottawa on November 6, 1960, Bhabha was reported to have said the U.S.S.R. had agreed to design natural uranium and fast breeder power stations for India. At the inauguration ceremonies, he gave no further information on the agreement, nor to date has the Consulate General been able to develop any.

Prime Minister Nehru in a speech described by the press as "one of the most scathing", "one of the fightingest" of his career--attacked those of "limited vision and restricted thinking" who questioned the economics of a reactor program at this stage of India's economic development. Referring to India's "epic struggle to revolutionize the life in her 550,000 villages", he asserted, "We do not want tomorrow to slip out of our hands by getting entangled with the problems of today." He spoke at length of nuclear energy as a great power for good but recognized that "its other use could not be ignored lest all our good thoughts and deeds be swept away." The Prime Minister did not elaborate on the latter remark, which seemed, however-to refer to India's well known stand against the use of atomic weapons; nor did this remark elicit any comment in press or official circles, to the Consulate General's knowledge.

In his more recent speech, Nehru also paid tribute to the assistance India had received in her atomic energy program "not only from Canada but also from other countries which are advanced in the field, such as France, the United Kingdom, the United States, and also--to some extent--the Soviet Union."

<u>Facilities Formally Inaugurated</u>--The facilities that were formally inaugurated on January 16, 1961, were as follows:

1. Canada-India Reactor (CIR)--The reactor is a substantially modified version of the Canadian NRX reactor, in operation at Chalk River since 1947. It is fueled with 10 tons of natural uranium (half from Canada, half from the Fuel Element Fabrication Facility at Trombay) and is moderated by 21 tons of heavy water (from the U.S.). The cooling system is believed to be unique--consisting of a primary circuit of fresh water and an attached heat exchanger through which sea water flows in a secondary circuit from and back to the harbor via a 3,200 foot jetty. Exhaust air is discharged from a 400 foot stack, the highest in India. The function of CIR is fourfold--1) to establish the different characteristics of materials for other reactors under actual operating conditions of temperature pressure, and radiation field; 2) to assist in basic research in biology, chemistry, metallurgy, and physics, particularly in experiments on breeding the thorium which India has in abundance into fissile U-233; 3) to produce radioisotopes; and 4) to provide training and experience for DAE personnel. The Reactor went critical on July 10, 1960, and has gradually been worked up to a power level of 17.5 megawatts, the highest any reactor in Asia has achieved so far. By mid-1961, it may be operating at the maximum power output of 40 MW. The decision to build the reactor was made in 1954 and an offer of assistance

was advanced by Canada under the Colombo Plan. Final discussions were held in Geneva in 1955 at the time of the First U.N. Conference on the Peaceful Uses of Atomic Energy and a formal agreement was signed in New Delhi in April 1956. Construction had been started in December 1955 by Indian Rare Earths Limited, a public sector company. Atomic Energy of Canada Limited originally planned to complete work by 1957. The peak employment of Canadian engineers was 32. The last four left in December 1960. It has been reported that the original estimated cost was $5.5 for equipment, $2.0 for engineering, and Rs. 3.5 crores ($7.35) as the Indian contribution or a total of $14.85 million. The final cost is now put at Rs. 11.4 crores ($23.94 million), split about evenly between India and Canada. The day before the opening ceremony, a final grant of $600,000 was announced by Mr. Churchill as part of Canadian assistance to India under the Colombo Plan for 1960-61, amounting to $25 million. The Reactor project is the largest so far undertaken in the field of international cooperation in the peaceful uses of atomic energy. When it reaches full power, CIR will be one of the largest research and isotope producing reactors in the world. Enclosure No. 4 provides further details on CIR. Bombay despatches on the subject include D-211, September 25, 1959; D-182, September 14, 1959, and D-549, April 20, 1960.

2. Uranium Metal Plant--This small plant is designed to purify the crude uranium fluoride obtained as a by-product of the Thorium

Plant at Trombay and so produce nuclear pure uranium for CIR and the other natural-uranium fueled research reactor, ZERLINA. Its capacity at present is 30 tons of uranium ingots a year, with scope for expansion up to 100 tons a year. Entirely an Indian project, it was started in December 1957 and went into regular operation in April 1959. The plant also serves to collect operational data and train personnel for larger units to be set up in the future.

3. Fuel Element Fabrication Facility--Another all-Indian project, the Facility converts the ingots produced at the Uranium Metal Plant into fuel elements for the CIR (for which it has manufactured half the requirement) and for ZERLINA (for which it has manufactured all). It also makes thoria pellets for irradiation in the CIR to produce U-233. Like the Uranium Metal Plant, the Facility has a capacity of 30-40 tons a year, with scope for expansion up to 100 tons. As such, the two plants are said to be ultimately sufficient to supply the annual feed for a nuclear power station of 250 MW. (The first station planned--at Tarapore, north of Bombay--will have a capacity of 300 MW.) The Facility, however, is not intended to be full scale. Nor does it wholly process the fuel elements: pending the completion of a Central Workshop at Trombay, the end pieces of the elements are machined at the Hindustan Machine Tools Limited, a public sector plant at Bangalore, Mysore State, and at a small temporary workshop at the Tata Institute of Fundamental Research, the national

center for advanced study in nulear science and mathematics in Bombay. The first prototype fuel element was produced in June 1959. Two others were sent to Chalk River for testing and reportedly are still in use. The cost of the installation has been put at Rs.81 lakhs ($1,710,000), of which Rs. 40 lakhs ($840,00) was foreign exchange. The Facility reportedly now saves the GOI Rs. 45 lakhs ($945,000) annually in foreign exchange. It also is said to entitle India to the claim of being the first Asiatic country to produce its own nuclear fuel elements.

4. ZERLINA--India's third research reactor, ZERLINA is a Zero Energy Reactor for Lattice Investigations and New Assemblies. Its maximum designed power level is only 100 watts and so no coolant is needed. From the lattice girders on its top, various types of fuel elements can be suspended; at present, they consist of natural uranium mixture of the two, or an organic liquid. The moderator currently consists of 15 tons of heavy water, provided by the U.S. AEC on July 1, 1959 under a lease arrangement that permits the GOI to suspend its usual objections to safeguards and to allow inspection in this instance on the grounds that material concerned is not Indian-owned. The reactor is to carry out experiments on various fuels and moderators--in different ratios, at different moderator temperatiures, and with different lattice spacing--in order to determine optimum configurations for future reactors. Designed and erected entirely by the Engineering

Division of the Atomic Energy Establishment, ZERLINA was scheduled to begin operation in the summer of 1958. However, construction of the building in which it was to be housed was delayed and the reactor itself was not started until the spring of 1960. ZERLINA went critical on January 14, 1961, two days before the opening ceremony. Its cost has been put at Rs. 10 crores ($21 million).

5. Heavy Water Reprocessing Plant--Started in January 1960, the plant was to be commissioned in August but did not get into operation until December 10, 1960. Yet another all Indian effort, the plant is to reconcentrate heavy water that has become "downgraded" while serving as moderators in the CIR and ZERLINA by the absorption of ordinary-water vapor or accidental mixing with ordinary water.

Existing and Future Facilities--With the inauguration of the five installations described above, the following outline can be drawn up of the facilities of the Atomic Energy Establishment, Trombay. Detailed descriptions are available in Enclosure No. 5, a special issue on nuclear energy of the magazine "Industrial India" published this month, and in Enclosure No.6, the Atomic Energy Department's Annual Report for 1959-60, covering developments through February 1960.

I. Reactors for Research and Development.

1. Apsara--Indian's first reactor, Apsara was started in May 1955, went critical on August 14, 1956, and commenced around-the-clock operation in November 1958. Designed and built entirely by Indian

engineers, Apsara (the name of a species of celestial water nymph from Indian Mythology) is a 1 MW reactor of the "swimming pool" type, moderated by ordinary water and fueled with 40% enriched uranium provided by the U.K. Atomic Energy Authority. After operation for some 2.2 million kilowatt hours at a progressively higher annual rate, the reactor was closed down in early August 1960 for maintenance work, repairs, and improvements. Scheduled originally for recommissioning in November, Apsara suffered a fortnight's delay and resumed operation in mid-December 1960.

2. CIT--40 MW, heavy-water moderated, natural uranium fueled

3. ZERLINA--100 watt, currently heavy-water moderated, natural-uranium fueled.

II. Production Facilities

1. Thorium Plant--described as one of largest in world; from crude thorium hydroxide, produces pure thorium nitrate for gas-mantle and other industries, uranium fluoride for Uranium Metal Plant, and thorium oxide for production of U-233.
2. Uranium Metal Plant--just inaugurated.
3. Fuel Element Fabrication Facility--just inaugurated.
4. Heavy Water Reprocessing Plant--just inaugurated.

5. Used Fuel Reprocessing of Plutonium Plant (Project Phoenix)--a small pilot plant for the recovery of plutonium from irradiated fuel elements; now under construction, scheduled for completion in 1962.

6. Stable Isotopes Plant--designs under study.

7. Central Workshop--under consideration; to serve functions now fulfilled by Hindustan Machine Tools Limited, Bangalore, Mysore State, etc.

8. Graphite Workshop--has machined the 50 tons of graphite for thermal column in CIR, a process originally expected to be done in Canada.

III. Research Activities

A. Physics Group, consisting of following Divisions

Theoretical Physics and Applied Mathematics

Nuclear Physics (has 5.5 Me V Van de Graff accelerator, expected to go into operation this year)

Reactor Control

Air Monitoring

Health Physics

Electronic (in 1950-60, produced 713 electronic instruments or some Rs. 10 lakhs/$210,000 worth)

B. Chemistry Group, consisting of following Divisions

Analytical

Chemistry

Radiochemistry

Isotopes

C. Engineering Group, consisting of following Divisions

Reactor Engineering

Chemical Engineering

Metallurgy

D. Biology and Medical Group, consisting of following Division

Medical and Health

Biology, consisting of following Sections

Radiation Genetics and Radiobiology

Biochemistry

Organic Chemistry

Plant Physiology

Food Irradiation

IV. Other Activities

Mass Spectrometer and Scintillator Projects

Scientific Information Division (abstracting and translations)

Training School

Department of Atomic Energy--In order to put the new installations further into context, it should be noted that the Atomic Energy Establishment under which they fall is but one part of the Department of Atomic Energy, a Ministry-level body, of which Nehru himself is the Minister and Bhabha the Secretary. The Department is assisted and guided by an Atomic Energy Commission of three members--Dr. Bhabha, Chairman; P. N. THAPAR, Member (Finance); and Dr. K. S. KRISHNAN, Member (Science). The Department's activities may be summarized as follows:

I. Atomic Minerals Division--During 1959-60, with a staff of 724 technicians and administrators, the Division engaged in surveys for uranium and thorium by air, by "radiation jeep," and on the ground and also in exploratory mining. Reserves of uranium ore, for the most part in Bihar and Rajasthan, have reportedly been proven adquate to produce 400 tons of uranium metal--enough to serve the first 300 MW power station for more than 10 years. Thorium deposits, mainly along the Kerala and Madras coasts and in Bihar, are estimated at over 500,000 tons, the largest in the world. The Division maintains physics, mineral technology, petrology, and chemistry laboratories It also encourages the public to explore for radioactive minerals by loaning out Geiger counters free of charge.

II. Mining and Industrial Operations

A. Travancore Minerals Limited--A public-sector company organized in 1956, it has taken over the Government Minerals Concern of Madras State and with capital now held 50% by the GOI, 45% by Kerala State, and 5% by Madras, it is one of the three major firms engaged in mining and processing the mineral sands of Kerala and Madras. The most abundant mineral constituent in the sands is ilmenite, the bulk of which is exported for industrial uses in the United Kingdom and the United States. From the tailings of ilmenite production, monazite is separated. The sands also are rich in rutile (from which titanium metal can be extracted) and zircon (whence comes zirconium metal, now gaining acceptance as a structural material in nuclear and chemical engineering).

B. Indian Rare Earths Limited--This company, owned jointly by the GOI and Kerala State, receives the monazite sand and in a plant at Alwaye (Kerala State), opened in 1952, separates the constituent parts: rare earths, trisodium phosphate, and thorium and uranium. The latter are then sent for further processing to Thorium Plant at Trombay, also operated by Indian Rare Earths Limited.

C. Ore-dressing Plant, Ghatsil (Bihar State)--A pilot plant has been set up attached to the Indian Copper Corporation to recover uranium from the tailings of copper ore, but from an economic point of view, recovery is still not satisfactory.

D. Heavy Water Facility, Nangal (Punjab State)--Part of the Government's Nangal Fertilizer plant, this facility is scheduled to go into operation by the end of this year and to produce 15-20 tons of heavy water annually. Linde of West Germany is reponsible for supply, erection, and commissioning, and Vitro International, New York, have been retained as consultants and architect-engineers.

E. Graphite Plant--The question of setting up such a plant is now under consideration. Graphite, like heavy water, is used as a moderator of neutron bombardment to increase the likelihood of nuclear fission; it is also used as a reflector to bounce neutrons back into the core of a reactor.

III. Research Activities

A. Atomic Energy Establishment, Trombay

B. Tata Institute of Fundamental Research (in physics and mathematics), partially supported by the DAE

IV. Office of the Officer on Special Duty (Power), Bombay-- This office is to plan and supervise the setting up of nuclear power plants in India. The first is definitely scheduled for the Third Five Year Plan--a 300 MW, heavy-water moderated, probably natural-uranium fueled plant at Tarapore, north of Bombay (see Bombay despatch 248, October 14, 1960, and previous, also page 42-43 in Enclosure No. 5). A second plant has been proposed during the Third Plan for the Delhi-Punjab-Rajasthan area--150 MW, natural-uranium fueled (see Bombay telegram 292, January 14, 1961, and G-392, January 14, 1961). However, no mention of it was made either in the publications issued or the speeches made in the course with the inauguration week's activities.

<u>Over-all Program</u>-- The new installations and the others described above are pointed toward several objectives--basic research; the production of radioisotopes for use in agriculture, biology, industry, and medicine; and the development of a self-sustaining system of generating electrical power through nuclear energy. With respect to the last objective, the Controller of the Atomic Energy Establishment, E. D. ALLARDICE, writes on page 3 of Enclosure No. 5 as follows:

"The programme is, briefly, to set up in stages three types of power reactors which, in addition to producing electricity, also produce fuel for other reactors: in the first stage natural uranium after appropriate purification is fed as fuel to a reactor; when this uranium fissions the irradiation converts some of the uranium 238 into plutonium--another element which, like uranium 233, does not exist in nature and can also be used as a fuel. In the second stage, when sufficient plutonium has been produced, it is used as a fuel in another type of reactor, and surrounded by thorium; as a result of irradiation, some of the thorium is converted into uranium 233. In the third stage, when a sufficient quantity of uranium 233 has been produced, it is used as fuel in yet another type of power reactor in which thorium is again introduced; the thorium is again converted into more uranium 233 and in fact produces more than is actually consumed. Theis type of reactor is known as a "breeder" reactor and all that is required to feed it is additional thorium--of which India has a super-abundant supply."

For the Consul General:

/s/Sidney Sober

Sidney Sober
American Consul

Addendum D

January 24, 1961

FROM : AMCONSUL, BOMBAY, INDIA

TO : The Department of State, Washington

SUBJECT: ATOMIC ENERGY: Symposium on Nuclear Power, Bombay

SUMMARY

At a Symposium on Nuclear Power held in Bombay during the two days following the inauguration of the Canada-India research reactor and other facilities at Trombay on January 16, 1961, the two prominent Canadian representatives spoke of the advantages to their country of the heavy-water moderated system of power reactor which they favor. The French touched incidentally on natural gas as a conventional alternative to nuclear power, an alternative rarely mentioned by the Indian Atomic Energy Commission in its defense of the economics of its own power program. The Russian delegate, V. S. EMELYANOV, could not come and was replaced by O. D. KAZACHKOVSKIY, described as Scientific Director of the BR-5 Fast Reactor. Possibly against the background of an announcement of a broad agreement between India and the U.S.S.R. on fast and natural uranium reactors,his speech reportedly elicited more questions from the large audience than any other. Sir Roger MAKIN of the U.K. spoke forcefully on the necessity for early actual experience in building a power reactor in a nuclear power development program in scientifically advanced countries. The U.S. speakers, Dr. Robert E. WILSON, Commissioner, AEC, and Dr. Robert A. CHARPIE, Oak Ridge National Laboratory, concluded the

Symposium with a summary of the U.S. reactor program (copy attached) and an address on the role of thorium systems in nuclear energy production.

* * *

Following the inauguration of the Canada-India research reactor and other facilities at Trombay by Prime Minister Nehru on January 16, 1961 (see Bombay despatch 435, January 24, 1961), the Indian Department of Atomic Energy held a Symposium on Nuclear Power at the Regal Cinema in Bombay on January 17-18, 1961. At each of the four meetings, both orchestra and balcony of the theater were crowded with Indian members of the Deaprtment staff, students, engineers, and scientists. Many questions were reportedly put to each of the speakers, and it was only with reluctance that the theater was surrendered in the afternoon to the devotees of the current offering at the Regal, Elvis Presley in "GI Blues."

The program of the Symposium was to have the leaders of the major foreign delegations, in each instance an important official of the Atomic Energy Commission of the country concerned, review the past progress and future plans of the country in the nuclear power field, and then have the eminent scientists in the delegations deliver addresses of a more technical nature on a particular phase of reactor development of interest or applicability to the Indian scene.

The consulate Genereal has been informed that the speeches will be published. At that time copies will be forwarded to the Department. Meanwhile, the following observations are offered by a Consulate General officer without technical training who attended part of the first three meetings and all of the last.

Canada

On the morning of January 17, 1961, after introductory remarks by Dr. Homi BHABHA, Chairman, Indian Atomic Energy Commission and Secretary, Department of Atomic Energy, Mr. J. L. GRAY, President, Atomic Energy of Canada Limited, described the Canadian approach to nuclear power, with its emphasis on the use of heavy water as a moderator. He asserted that such power reactors had been found most suitable to the Canadian scene and also extremely flexible. Dr. W. B. LEWIS, Vice President, Atomic Energy of Canada Limited, followed with an address, not heard by the Consulate General observer, entitled "Designing Heavy Water Reactors for Neutron Economy and Thermal Efficiency."

France

In the afternoon, Prof. F. PERRIN, member of the French Academy of Sciences and High Commissioner, Commissarist de l'Energie Atomique, spoke on the French nuclear power program. At one point he referred to the improvement in France in the matter of low cost and high efficiency of conventional power, stating that a new major source for such power would be available in the future in natural gas piped under the Mediterranean from the Sahara. This portion of the speech had particular pertinence to India inasmuch as there are reserves of natural gas in Sui and Mari, across the Rajasthan border in Pakistan; some effort has been made by the Government to arrange for import of a supply of this gas; and the Mari field may extend into Rajasthan itself. Yet rarely in the defenses offered by the Indian Atomic Energy Commission of the economics of nuclear power reactor construction at the present stage of India's development, is natural gas ever mentioned along with coal, hydro-electricity, and oil as a source of power as an alternative to and competitive with nuclear evergy. In another speech, not heard by the Consulate General representative, M. J. HOROWITZ, Chief of the Department of Study of Atomic Piles, Commissariat de l'Energie Atomique, spoke on a project for a power reactor moderated by heavy water, with extraction of heat by gases under pressure.

U.S.S.R.

On the opening morning of the next day, January 18, 1961, Professor V. S. EMELYANOV, Corresponding Member of the Soviet Academy of Sciences, Chairman of the State Committee of the Council of Ministers for the peaceful Utilization of Atomic Energy, and a visitor to India in early 1960, was scheduled to speak, together with "another representative" of the U.S.S.R. At the last minute, however, Emelyanov could not come to attend the week's event, on the occasion of the opening of the facilities at Trombay. He was replaced by Oleg D. KAZACHKOVSKIY, a tall rough-hewn man in his early forties, described as the Scientific Director, BR-5 Fast Reactor (location not specified). Through a "simultaneous translation" which actually was a reading of his paper in [illegible] from the translator's booth while Kazachkobskiy mumbled Russian words almost inaudibly from the rostrum, a technical description of the BR-5 was given. Little of the speech was comprehensive to the Consulate General observer. It appears that the BR-5 is a 5 MWe or 100 MWt reactor and represents a pilot project for two larger power-producing fast reactors of 50 MWe and 250 MWe. The subject proved of interest to the audience, perhaps in relation to

Dr. Bhabha's repetition at the opening ceremonies on January 16, 1961, of the annoucement that India had negotiated a broad agreement with the U.S.S.R. on fast and natural-uranium reactos. According to a number of observers, Kasachkovskiy's address elicited more questions than any other during the symposium. A spirited but friendly exchange arose between Kazachkovskiy and Dr. Lewis, of Canada, when the former attempted to dispel the pessimism the latter had expressed in his speech concerning the future prospects of fast reactors. Kazachkovskiy ended the discussion by proclaiming that it was by the joint experience of all countries in nuclear power development that the optimum reactors would be achieved.

United Kingdom

On the afternoon of January 18, Sir Roger MAKINS, Chairman, U.K. Atomic Energy Authority, delivered a forceful address on nuclear power policy in the United Kingdom. In it he mentioned the "stretch-out" which England's nuclear power program had had to undergo when following an overly dire forecast in 1955 of conventional power potential and the initiation of an accelerated program to build nuclear power reactors, it was later found that conventional power costs actually were dropping while long-term interest and development costs on the reactors rose. Still Sir Roger felt that cost per kilowatt hour from nuclear power in England would fall below that from conventional power by the end of the present decade. He also went on to argue cogently on the subject of the economics of power reactor development raised in Professor Perrin's speech. The Frenchman had implied and Makin now stated that the justification of power reactor development in a scientifically advanced country lay elsewhere than in economic considerations over the short and medium term. It lay instead in the necessity--given the vast areas of the unknown in nuclear power--for each such country to move ahead with building its own reactor and thereby gain the experience and knowledge necessary to launch an economic program of power generation by nuclear means. Study of design or profiting from the material developed in the programs of other countries are not enough, he said. The scientifically equipped nation must make its own mistakes if an economic power reactor suited to its needs is ever to be developed. In a third and final address and discussion not attended by the Consulate General representative. Sir John COCKCROFT, inter alia a member of the U. K. Atomic Energy Authority, continued with tangible illustrations of Makin's theme in a speech entitled "The British Experience in the Technical Development of Nuclear Power."

United States

On the same afternoon, Dr. Robert E. WILSON, Commissioner, AEC, and leader of the U. S. delegation to the opening ceremonies, summarized the U. S. reactor program. Six copies of his speech are attached as Enclosure No. 1. Dr. Robert A. CHARPIE, Assistant Laboratory Director (Reactors), Oak Ridge, followed with a paper on the role of thorium systems in nuclear energy production, a subject of interest in view of the large thorium deposits in India. Six copies of a news release on this speech and Dr. Wilson's, as put out by United States Information Service, are attached as Enclosure No. 2.

For the Consul General:

/s/Sidney Sober

Sidney Sober
American Consul

ERDA file of 3/27/56

Addendum E

ABSTRACT OF DEPARTMENT OF STATE REPORT ON NUCLEAR POWER POTENTIAL IN INDIA MAY 17, 1955

Possibly no underdeveloped country has evidenced such active interest as India in atomic energy as a new source of power. H. J. Bhabha, Chairman of India's Atomic Energy Commission, will be president of the forthcoming United Nations Geneva Conference on Atomic Energy. In 1953, Dr. Bhabha is quoted as stating that atomic energy offers the "only chance" of raising the standard of living of India's and Pakistan's combined populations of 450,000,000.

However, the capital costs of nuclear power plants must be reduced substantially below present levels before they can compete with conventional thermal plants in India. As long as India's electric power system has a low rate of capacity utilization, the prevailing higher overhead charges for nuclear power attributable to heavier investment costs will outweigh any possible savings in the fuel element. Even if one makes the unlikely assumption that India will be able to construct nuclear power plants in the near future as cheaply as the U.S. and that the cost of fissionable materials will be negligible, nuclear power plants would have to achieve a capacity utilization rate of 50 percent in India to compete with conventional thermal plants in average cost coal areas. The present average capacity utilization is 30 percent at most. Nuclear power will yield moderate savings under the above assumptions as to investment costs and a 50 percent capacity utilization rate only where coal costs are approximately double the national average, as they apparently are in Travancore-Cochin. The achievement of these savings will be limited to large power stations of about 100,000 kw. Smaller nuclear plants would have substantially higher generating costs which would diminish or eliminate any savings. The size factor may further restrict the opportunities of utilizing nuclear power in India since up to the present the demand for large steam power stations has been limited. In 1952, only seven of India's 90 steam plants had a capacity of 50,000 kw or larger. Finally, the prospect of some improvement in India's transportation system and the exploitation of large low-cost lignite deposits south of Madras may well lower relative coal costs in the next few years.

Over the longer run technological progress may well cut the capital costs of nuclear plants to the level of conventional plants as well as reduce the nuclear fuel charge to a negligible amount. In this event nuclear power, in the absence of an increase in capacity utilization and on the basic of present conventional power costs, would yield maximum savings of 4.9 mills per kwh or about 28 percent of total power generation costs in the highest cost coal areas. Such savings would contribute to but by no means eliminate the major obstacles to India's economic growth.

Addendum F

June 12, 1974

A. S. Friedman, Director, International Programs

TARAPUR SHIPMENT SCHEDULED FOR JUNE 17

In order to make sure that there is a complete understanding on this matter, the following is the basis on which I am now proceeding:

1. The Chairman (T. Rehm) has asked that the Tarapur shipment be held up, if necessary, until DIP has made a recommendation to the Commission on Tarapur safeguards and other relevant matters. Hopefully, this would take place before the scheduled shipment on June 17. My understanding is that Bill Yeomans will follow through on this.

2. NSC (Elliott) has contacted "the White House at Salzburg" and advises that the Tarapur shipment is not to be held up for "political reasons". If there are technical problems with the safeguards it might be held up, but NSC would like to know if we anticipate any such problems as soon as possible.

In view of the foregoing--and particularly item 2--I am taking no specific action at this time to stop the shipment. Pete and I would be glad to discuss with you the implications of stopping the shipment were it to become necessary.

Original signed by D. B. Hoyle

Dixon B. Hoyle, Assistant Director
for Supply and Market Policy
Division of International Programs

cc: IP:ADA&L
IP:M&S
OGC

SECY-75-74

July 23, 1974 AEC INFORMATION REPORT

NOTE FOR: Chairman Ray
Commissioner Doub
Commissioner Kriegsman
Commissioner Anders

THRU : General Manager

RESPONSE FROM INDIAN AEC CHAIRMAN TO CHAIRMAN RAY'S JUNE 19 LETTER RE ASSURANCES ON TARAPUR FUEL

Enclosed is a copy of a letter dated July 10, 1974, from Indian AEC Chairman Sethna to Chairman Ray, transmitted to the State Department by the Indian Ambassador in response to Dr. Ray's letter of June 19, 1974, in which assurances were requested on non-PNE use of US-supplied material or equipment for the Tarapur atomic power project. The original of the enclosed is being sent over from State. A copy of Dr. Ray's June 19 letter is also enclosed for information.

Staff recommendations relating to the Indian letter are under consideration.

A. S. Friedman, Director
Division of International Programs

Enclosures:

1. Ltr dtd 7/10/74 frm Indian AEC Chairman
2. Ltr dtd 6/19/74 to Indian AEC Chairman

June 19, 1976

Dr. Homi N. Sethna, Chairman
Indian Atomic Energy Commission
Chhatrapati Shivaji Maharaj Marg
Bombay 1, India

Dear Dr. Sethna:

As you are aware, a five-part shipment of enriched uranium fuel for the Tarapur reactors has been scheduled for the period between June 15, 1974 and April 1, 1975. Delivery is being made of the initial portion of this shipment.

In this connection, the United States Government wishes to emphasize its understanding, expressed most recently by the U.S. representative to the IAEA Board of Governors on June 12, 1974 (1) that the use in or for any nuclear explosive device of any material or equipment subject to United States Agreements for Cooperation in Civil Uses of Atomic Energy is precluded and (2) that under the safeguards agreements related to such Agreements for Cooperation, the IAEA is responsible for verifying, inter alia, that the safeguarded material is not used in or for any nuclear explosive device. The United States Government has permitted this initial part of the shipment to proceed only on the basis of the foregoing understandings and on the assumption that the Government of India will respect these understandings.

The United States Government requests confirmation by the Government of India, prior to the date of the next scheduled portion of the shipment, that it will take no actions which are inconsistent with the foregoing understandings.

Sincerely,
(Original signed by Dixy Lee Ray)
Chairman

bcc: SECY (3)
GM
OGC
E. Giller, GM
W. Yeomans, IP
J.Poor, ISA
REG
AA/LA, IP
D.Hoyle, IP

IP AGMA IAGM DGM GM

FRIEDMAN:ked

Comm. Larson concurs.
Comm. Kriegsman concurs.
Comm. Anders noted, but would have preferred withholding current initial shipment until response fm Indians was obtained

Comm. Doub agrees with Anderson would like to have discussed at Comm. mtg.

Government of India
Atomic Energy Commission

Office of the Chairman

10 July 1974

No. 272-74

Dear Dr. Ray,

Please refer to your letter dated June 19, 1974 which was handed over to our Ambassador at Washington.

2. The Government of India regrets that it is unable to share the understanding of the United States Government expressed recently by the United States Representative to the IAEA Board of Governors on June 12, 1974 (1) that the use in or for any nuclear explosive device of any material or equipment subject to United States Agreements for Cooperation in Civil Uses of Atomic Energy is precluded; and (2) that under the safeguards agreements related to such Agreements for Cooperation, the IAEA is responsible for verifying, inter alia, that the safeguarded material is not used in or for any nuclear explosive device. The Government of India is of the opinion that this understanding does not flow from the Agreement for Cooperation between the two Governments concerning the construction and operation of the Atomic Power Station at Tarapur.

3. Under Article II of the Agreement, the United States Atomic Energy Commission has contracted to sell to the Government of India all requirements of enriched uranium for use as fuel at the Tarapur Atomic Power Station, it being understood that the Tarapur Atomic Power Station shall be operated on no other special nuclear material than that made available by the United States Atomic Energy Commission and special nuclear material produced therefrom. Under Article VI, the parties to the Agreement have emphasised their common interest in assuring that any material, equipment or device made available to the Government of India for use in the Tarapur Atomic Power Station, or in connection therewith, pursuant to the Agreement shall be used solely for peaceful purposes. However, the Government of India had emphasised in this Article, in contrast to the position of the United States, that its agreement to the provisions of Article VI was accorded in consideration of the fact that the Tarapur Atomic Power Station will be operated on no other special nuclear material than that furnished by the United States Government and special nuclear material produced therefrom. The safeguards provisions of Article VI of the Agreement for Cooperation were later on transferred under a Trilateral Agreement to the International Atomic Energy Agency.

4. I would like also to draw your attention to Clause F of Article II of the Agreement for Cooperation under which the United States Government has the first option to purchase the special nuclear material produced in

(4)

the Tarapur Atomic Power Station which is in excess of the need of the Government of India for such material in its programme for the peaceful uses of atomic energy. I would like to state that the Government of India is prepared to return to the United States Government special nuclear material produced in the Tarapur Atomic Power Station at a mutually agreed price except a quantity which could be required for recycling in the Tarapur Atomic Power Station as provided under Clause A of Article II, the amount being arrived at after mutual consultations.

5. May I suggest that in case the U.S. Government wishes to incorporate changes in the existing agreement, that we meet and discuss this matter? If you will recollect, you have agreed to visit India this year and this matter could be discussed and finalised at that time.

6. In the meantime, I hope that my suggestion regarding special nuclear material produced in the Tarapur Atomic Power Station would be acceptable to the U.S. Government and that there will be no difficulty in the United States Atomic Energy Commission adhering to the shipments of enriched uranium and other materials need for use at or in connection with the Tarapur Atomic Power Station.

With best wishes,

Yours sincerely,

(H. N. Sethna)

Dr. Dixy Lee Ray
Chairman
U.S. Atomic Energy Commission
Washington
U.S.A.

HNS:kv:
10-7-74

August 29, 1974

NOTE FOR: David N. Jenkins, Technical Assistant
to the Chairman

STATUS OF TARAPUR SAFEGUARDS SITUATION

On August 27, 1974, a representative of the Indian Embassy called at the State Department to deliver the official Indian response to our proposed reply to Dr. Sethna's letter of July 10.

The attached letter shows the Indian proposed deletion. Also included is a draft U.S. counterproposal which accepts the Indian deletion but then modifies the last phrase of that sentence. This counterproposal was prepared by State and informally concurred in by NSC. OGC is currently reviewing it.

The Indian representative was advised that their proposed deletion caused us some concern in view of possible ambiguity in the remaining language and that after reviewing this we would be back in touch with them.

Gerald F. Helfrich
Deputy Director
Division of International Programs

Attachment:

Draft Letter to Dr. Sethna

PROPOSED REPLY TO DR. SETHNA'S
LETTER OF JUNE 10, 1974

Dear Dr. Sethna:

Thank you for your letter of July 10 responding to miné of June 19 concerning shipments of enriched uranium fuel and other material to the Tarapur atomic power station.

Your response leads us to believe that we may not have made sufficiently clear the nature of the assurance we need. What we ask is simply written assurance from your government that the special nuclear material that has been or is hereafter made available for, or used or produced in, the Tarapur atomic power station will be devoted exclusively to the needs of that station or other agreed purposes* (that do not include use in a nuclear explosive device).**

We look forward to hearing from you on this in order that we may promptly proceed with further shipments.

Sincerely,

Dixy Lee Ray

---

*US counterproposal would read: "or other purposes which will be mutually agreed by the two governments."

**Indians want this deleted.

September 11, 1974

Paul C. Bender, Secretary

TARAPUR FUEL

SECY 75-90B, Tarapur Fuel, requests Commission concurrence in a proposed exchange of letters between Chairman Ray and Indian Atomic Energy Commission Chairman Sethna concerning shipments of enriched fuel and other material to the Tarapur atomic power station. This paper had been scheduled to be discussed at a Commission meeting on the morning of Tuesday, September 10. The September 10 meetings of the Commission, however, were cancelled and at the request of Chairman Ray, I polled the Commissioners individually.

The course of action proposed in SECY 75-90B was approved by Chairman Ray, Commissioner Anders, and Commissioner Kriegsman, and the State Department and the National Security Council are informed that this course of action now has Commission approval.

A. S. Friedman, Director
Division of International Programs

September 16, 1974

Dr. Homi N. Sethna
Chairman
Atomic Energy Commission
Bombay, India

Dear Dr. Sethna:

Thank you for your letter of July 10 responding to mine of June 19, 1974 concerning shipments of enriched uranium fuel and other material to the Tarapur Atomic Power Station.

Your response leads us to believe that we may not have made sufficiently clear the nature of the assurance we need. What we ask is simply written assurance from your Government that the special nuclear material that has been, or is hereafter made available for, or used or produced in, the Tarapur Atomic Power Station will be devoted exclusively to the needs of that station unless the two Governments hereater specifically agree that such material be used for other purposes.

We look forward to hearing from you on this in order that we may promptly proceed with further shipments.

Sincerely,

Dixy Lee Ray

Government of India
Department of Atomic Energy

September 17, 1974

Office of the Secretary

Dear Dr. Ray,

I thank you for your letter dated 16th September 1974.

The Government of India would like to reassure the Government of the United States of America that the special nuclear materials that has been or is hereafter made available for, or used, or produced in the Tarapur Atomic Power Station located at Tarapur will be devoted exclusively to the needs of that Station unless our two Governments hereafter specifically agree that such material be used for other purposes.

I hope that with this assurance, the United States Atomic Energy Commission will promptly proceed with further shipments.

With best wishes,

Yours sincerely,

(Homi N. Sethna)

Dr (Miss) Dixy Lee Ray
Chairman
United States Atomic Energy Commission

10

Addendum G

New Delhi -- List of Interviews by Albert and Roberta Wohlstetter

April 15-22, 1966

Indian Council of World Affairs	S. L. Poplai, Secretary-General S. P. Godrej, Honorary Secretary Bombay Branch
Indian School Of International Studies:	M.S. Rajan, Director
National Defense College:	Col. Pyara Lal
Economists:	A. K. Sen, University of Delhi Mrs. Kumar, University of Delhi P. N. Dhar, Director Institute of Economic Growth
Members of Parliament:	Krishna Chandra Pant Mrs. Sharda Mookerji S. N. Mishra (assoc. w/ econ.planning) Santokh Singh
Newspaper Correspondents:	Maharaj K. Chopra, Indian Express Rohit Handa, Asst. Ed., Indian Express (Also from The Patriot, The Times, the Hindustani Times Weekly, the Statesman - didn't catch their names).

GOI

Ministry of External Affairs
- C.F. Jha, Secretary General
- V.M.M. Nair, Joint Secretary
- S. Gopal, Director of Historical Division (Policy Planning)

Cabinet Secretary: Mr. Dharma Vira (at the time also on a 4-man AE committee, replacing Bhabha-that part of his job is now taken by Sarabhai)

Ministry of Defense: Mr. P.V.R. Rao, Secretary

Ministry of Finance: Mr. S. Bhoothalingam, Secretary

Planning Commission: Pitamber Pant, Perspective Planning Chief

Mr. and Mrs. Romesh Thapar, editor Seminar

Military: Major Gen. K.C. Khanna, Deputy Master-General of Ordinance, Indian Army
Lt. Gen. M.M. Khanna, IV Corps Commander, Indian Army
Rear Adm. S.N. Kohli, Deputy Chief of the Naval Staff, Indian Army
Air Marshal P.C. Lal, Vice Chief of the Air Staff

American Embassy:	Mr. Joseph N. Greene, Jr., Deputy Chief of Mission Dr. Fuller, Science Attache Col. McKeever, Air Attache & his aide Emerson Gardener - AID Gordon Mannly - Power resources grp, AI Nick Veliotes - 1st Sec'y PE/EX Col. Gardner A. Williams, Army Attache

Rockefeller Foundation: Mr. Chadbourne Gilpatric

British Embassy: Terence O'Brien, political counsellor

Indians Interviewed in Canada and America

Major-General D. Som Dutt, on leave at ISS

M.J. Desai, formerly Secretary General, Department of External Affairs

Dr. Raj Krishna, economist on leave at M.I.T.

S. Bhagavantam, Science Advisor to the GOI Department of Defense

New Delhi -- List of Indians Interviewed by Albert Wohlstetter

31 March to 2 April 1967

Dr. A. Appadorai,
Member, Research Board
Indian Council of World Affairs,
New Delhi

K. S. Bajpai,
Director, No. American Bureau
Ministry of External Affairs
New Delhi

Dr. P.N. Dhar, Director
Institute of Economic Growth,
Delhi

Dr. S. Gopal, Chairman,
Research Borad,
Indian Council of World Affairs,
New Delhi

Shri Sisir Gupta,
Director of Research,
Indian Council of World Affairs,
New Delhi

L. K. Jha
Special Secretary to
the Prime Minister
New Delhi

Shri Girilal Jain,
Assistant Editor,
Times of India
New Delhi

Dr. Raj Krishna,
Department of Economics
University of Rajasthan,
Jaipur

Shri Jagat S. Mehta,
Joint Secretary,
Ministry of External Affairs,
New Delhi

Dr. B.D. Nagchaudhuri, Director
Saha Institute of Nuclear Physics,
Calcutta

Shri K.R. Narayanan,
Director (East Asia Division),
Ministry of External Affairs,
New Delhi

Mar. Gen. D.K. Palit, Commandant,
Indian Military Academy,
Dehra Dun

Shri S.L. Poplai,
Secretary General,
Indian Council of World Affairs,
New Delhi

Dr. M.S. Rajan, Director,
Indian School of International Studies,
New Delhi

Dr. Vikram A. Sarabhai, Chairman,
Department of Atomic Energy,
New Delhi

Major General Som Dutt,
Director, Institute of Defense Analyses
New Delhi

Shri Romesh Thapar, Member
Research Board,
Indian Council of World Affairs,
New Delhi

Dr. M. S. Venkataramani,
Indian School of International Studies
New Delhi

Shri B. George Verghese,
Press Advisor to the Prime Minister
New Delhi

Addendum H

SHALL WE LET INDIA SEPARATE SPENT FUEL FROM THE TARAPUR REACTORS?*

Albert Wohlstetter

1. The United States should refuse to allow the Indians to separate the spent fuel from the Tarapur reactors. We should also refuse to let the Indians recycle plutonium from any source in the Tarapur reactors.

2. Safeguards cannot be "effectively applied" to recycling in India. This key prerequisite for our approval -- stated in the Agreement for Cooperation -- cannot be fulfilled by any practicable accounting and inspection system applied to the Tarapur separation plant or to other critical points in a fuel cycle that involves manufacturing plutonium dioxide fuel and recycling it in the Tarapur reactors. This judgment interprets "effective application" of safeguards to mean assuring early detection, warning, and the possibility of counteraction before nuclear weapons are assembled. That interpretation has been at least implicit since the start of discussions on safeguards at the end of World War II and has been explicit in IAEA as well as in American official statements of recent years. No other interpretation makes sense.

3. While recycling will provide material for nuclear explosives, it is not needed for the purpose of producing electrical power, or for any other clearly economic purpose.

4. Measures that stop short of a ban on recycling will not prevent the Indians from legitimately accumulating large quantities of fissile material, chemically separated, of an isotopic composition ideal for weapons and essentially ready for insertion in bombs.

* I have drawn freely on the work of Gregory Jones, Vincent Taylor, and Roberta Wohlstetter. This piece was written for the Arms Control and Disarmament Agency on February 14, 1976, and deals with one point of policy under consideration at the time.

I. The Need for and the Difficulties of the Decision to Refuse Reprocessing at Tarapur *

a) A decision to let India reprocess the Tarapur fuel would have important effects: It would make it easy for India to get large quantities of separated plutonium, highly concentrated in Pu 239, ready within days or hours for insertion in a nuclear explosive. Letting them reprocess Tarapur fuel at all would legitimate recycling of plutonium there, and the problem is recycling, not merely reprocessing.

b) Analysis of the actual operating history of the Tarapur reactors and reprocessing plant shows that halfway measures of constraint will not do. Some current American proposals have this character. While permitting or even encouraging mixed plutonium and uranium oxide (MOX) fuel fabrication and plutonium recycling, they try merely to limit the amount of separated plutonium stocked at the output end of a chemical separation plant and combine this with tightening "safeguards." However, the plutonium in the unirradiated fresh MOX reloads at the front ends of the Tarapur reactors would be enough for nearly 100 bombs. With the large Tarapur and Trombay reprocessing plants, the plutonium in the fresh MOX fuel could be separated at the rate of five bombs worth a day. That plutonium would be in addition to what would be found in the starting and in-process inventories at the MOX fuel fabrication facility and the stocks at the output end of the separation plant, and in addition to plutonium obtained by "diversion" of a small percentage in violation of the Agreement. (It is only this last diversion that is usually considered when the bomb potential is described in terms of one or a few bombs per year.) But if an agreement permits recycling, then tightening "safeguards" to detect violations will not prevent the legal accumulation of the large stocks of plutonium

---

* This memorandum deals with the decision on whether or not to authorize India to reprocess Tarapur fuel. The considerations advanced, however, also raise questions about our continuing automatically to renew licenses for core reloads at Tarapur without asking whether Indian reprocessing is compatible with the basic purpose of our Agreement with India.

that are inherent in recycling. Such halfway measures would meet with vocal Indian resistance without accomplishing their purpose.

c) The history of our negotiations with the Indians over the question of safeguards makes plain that there is no way we can get controls assuring early warning without clearly disagreeing with Indian interpretations of the Agreement. If we accept the Indian interpretation, even nuclear explosives are peaceful. A precise, calmly stated U.S. disagreement should be regarded as a plus, not a minus. We should not hesitate to enforce our interpretation where we can. Moreover, in spite of many statements to the contrary, we have a great deal of leverage to use.

d) Any effective course of action will have to interpret our Agreement on Cooperation with the Indians rigorously in the light of its controlling purpose so as to exclude recycling. One such course of action would be to refuse to authorize reprocessing of the Tarapur fuel. I believe that we should do that and base the decision in the first instance on the fact that safeguards cannot be effectively applied to plutonium accumulated in the course of recycling if we mean by "effectively applied" a system of early warning that nuclear explosives are about to be made. (The President last May reiterated in a message to Congress on nuclear exports and safeguards that the purpose of safeguards is "early detection." This of course has been the main purpose of safeguards in the civilian nuclear export programs from the start. An inspection that is not designed to provide early warning can only euphemistically be called a "safeguard.") In the second place we can base our refusal on the fact that reprocessed fuel is <u>not</u> "needed" to fuel the Tarapur reactor in the sense that no adequate substitute is available. The plutonium derivable from the spent fuel at Tarapur would represent a very small proportion of the total enriched fuel requirements. The spent fuel accumulated and stored from the Tarapur reactors in the 5 years or so since they began commercial operation on October 3, 1969, contains some 241 kilograms of plutonium. This 5 year total amounts to about 9% of the fissile material that would be found in the Tarapur reactor cores.
Moreover the economics of recycling this amount of plutonium and substituting it in the form of mixed oxide for a fraction of the uranium oxide fuel is doubtful at best and in any case cannot substantially help kilowatt hour costs. It cannot be argued persuasively therefore that Tarapur <u>needs</u> to replace enriched uranium with plutonium fuel.

e) This justification for refusing the Indian request would construe the sense of "effective application of safeguards" and "need" very strictly in the light of the controlling intention of the Atoms for Peace agreements. It is, however, a common sense construction. Nonetheless it is bound to trouble some American officials concerned with the effect on the IAEA safeguard system, on other nuclear suppliers, and on our customers.

Some comments are in order on each of these concerns.

- <u>On the IAEA inspection system</u>: The IAEA inspection system is an accounting and inspection procedure designed to see that agreements under IAEA inspection are not violated, that materials are not "diverted" and that the limits of error of material unaccounted for are kept small. However, whether or not such a system will provide early warning depends on the nature of the agreement, on what is excluded and what is permitted. If agreements are formulated so loosely as to make it perfectly legal to accumulate stocks of plutonium in a form days or hours from insertion in a nuclear explosive, no search for violation of the agreement, no matter how diligent and "tight," will provide early warning. If we want to make IAEA inspection arrangements serve the purpose of warning, it is up to us to define the agreements so that a close approach to weapons is a violation. To say this does not undermine our support of the IAEA. It is a preface to making it effective.

- <u>On other nuclear suppliers</u>: Other exporting governments, like our own, have both an interest in the net gains from trade that might be made from an efficient unsubsidized nuclear export industry and an interest in curbing the spread of nuclear bombs. The gains from exporting reprocessing equipment, however, are in any case likely to be modest at best. Reprocessing so far appears on the basis of our study to be uneconomic, even in very large separation plants like that being constructed at Barnwell, with a capacity of 1500 MTU per year. It will be even more uneconomic in the smaller units required in the Third World. But if we were to suppose nonetheless that, in defiance of the economics, reprocessing were to become universal in small and large facilities everywhere, the demand for capital equipment for reprocessing would be small in relation to the demand for reactors. It would be perhaps two percent of the export market for reactors. Exporters might of course try to gain some special advantage in competition to sell reactors by tying reactor sales to an offer to supply separation plants to importers eager to get control of readily fissionable material. That, however, is precisely the sort of suicidal competition we are trying to discourage, and our willingness to forego it ourselves should in the future discourage the suspicion expressed by the Germans, for example, in connection with their Brazilian deal: namely that we ourselves were quite willing to offer a "complete fuel cycle" to our customers, or at least to see them get such a fuel cycle, and just objected to the Germans getting there first.

- On the customers: It goes without saying that if we insist on strictly construing "safeguards" and "needs" so as to prevent the legal acquisition of stocks of separated plutonium, we will displease India and other customers who have relied on our not being very serious on this subject. That may be somewhat uncomfortable for us, but we should regard it as inevitable if we are serious. We have already started to clarify and strengthen our position on reprocessing, and faltering on Indian reprocessing will only get us into more trouble. This is an important enough point to deserve a separate heading.

f) Beginning last summer, the U.S. government went a long way toward refining its strictures against reprocessing in the course of negotiating with South Korea. Its efforts were recently crowned with success, when the Republic of Korea cancelled its contract with France for a small separation plant. If we were now to authorize reprocessing by India it will suggest, and not only to the South Koreans, that we are much more willing to put the screws on our allies than on even the most provocative of the non-aligned. This will severely hamper the essential evolution of our policies with respect to Taiwan, Japan, Pakistan, etc.

g) If we fail to define our policy more rigorously in response to this Indian request, the Indian example will make quite clear that our claims are hollow that LWRs are safer than HWRs from the standpoint of avoiding the spread of weapons material.

What follows will elaborate first on an analysis of the Tarapur reactor and reprocessing plants and their weapons potential, and second on the need for interpreting our ambiguous Indian Agreement in our favor.

II. Weapons Potential and Economics of Indian Recycling

A. The Tarapur Reactors and Reprocessing in India

The Indians have operated their reactors in ways that can provide them with separable plutonium of an isotopic composition particularly well adapted to nuclear explosives, and they have built reprocessing facilities that can quickly separate the plutonium in spent fuel and even more quickly any plutonium recycled in fresh mixed oxide fuel.

. . .

The two LWR reactors at Tarapur have a rating of 190 MWe each. The operating history of these reactors since they started commercial operations on October 3, 1969, displays a very large divergence from the standard assumptions as to the normal operational pattern of LWRs, and an even larger divergence from early Indian predictions. Instead of the very high expectations the Indians entertained when they were considering nuclear power (capacity factors averaging as high as 80% throughout the life of the reactor) the actual factors have been about 45% for both reactors.* The average degree of burnup has been correspondingly low, and low burnup means relative freedom from the higher isotopes of plutonium less desirable for weapons. Moreover, the operating history has shown extreme irregularities with long periods of down time and with about 97% of the fuel bundles rupturing. (The Indians manufacture their own uranium dioxide fuel rods.) The low average burnup and the great irregularity of the Tarapur operation make it easy for the Indians to extract plutonium highly concentrated in the readily fissionable isotope plutonium 239. They can do that without any departure from their commercial "norm."

In spite of the many familiar statements about "denaturing" plutonium and the distinction usually made between high burnup "reactor grade" plutonium and

---

* U.S. expectations today are more modest than the initial Indian hopes. ERDA's recent projections show a 40% capacity factor between the time reactors go critical and when they are declared commercial; then 65% for the following two years; then between 70 and 75% for the next 13 years and then a decline to 40% at 2% per year. (Total Energy, Electric Energy, and Nuclear Power Projections: United States. February, 1975, p. 6. Unpublished document by ERDA.) If the Indians had followed this pattern, their reactors would have operated at 65% capacity between October, 1969, and October, 1971, and from October, 1971, on at between 70 and 75%. In fact throughout this period they have both operated at about 45%.

low burnup "weapons-grade" plutonium, even the plutonium produced in reactors operated with much greater regularity and with a much higher degree of burnup than at Tarapur would be usable in a nuclear explosive. Such an explosive made with high burnup reactor grade plutonium would have an expected energy yield 3 orders of magnitude larger per pound than a non-nuclear explosive despite the fact that the plutonium would be contaminated by 20 or 30% of the higher isotopes (Pu240 and Pu242) which are undesirable for bombs of standard design. It is important, nonetheless, to note that the Indians have been producing plutonium with much smaller amounts of the undesirable higher isotopes than are usually talked about in "reactor grade" plutonium. They will in fact have a great deal of separable plutonium that is ideal from a weapons standpoint. (This is explained and documented in II.-B.,C., and D.)

The second point worth observing is that the Indians have built separation plants whose capacity far exceeds that required to handle the spent fuel from the reactors that they will have in operation for many years to come assuming they do recycle. (A 100 MTU per year reprocessing plant at Trombay and at Tarapur at 150 MTU per year.) Recycling plutonium would be extremely uneconomical for the Indians even if their facilities were well matched to the output of their reactors both in quantity and in time. But they are not. This comparatively large reprocessing capability, however, puts the Indians in a position for quite rapidly separating large quantities of plutonium from the irradiated spent fuel. It also puts them in the position to separate even more rapidly the plutonium from the fresh, unirradiated fuel that they would have in large quantities if they recycle plutonium in their reactors. *

This separated plutonium, whether in the form of plutonium nitrate (as planned in the Tarapur reprocessing plant) or plutonium dioxide, would be about five days from Pu metal ready for insertion in a bomb. Nothing in the agreements unambiguously precludes their getting the metal itself -- that is to say, they could reduce the time before insertion into an explosive essentially to zero. In fact, as the Indians are fond of pointing out, nothing explicit in the agreement prevents them from exploding a "peaceful" nuclear device, though we have made clear our differing unilateral understanding on the subject.

* This is true because the plutonium is more concentrated in fresh MOX fuel than in the spent fuel. This is true even though the MOX fuel made by some methods would require an extra step in reprocessing. The fresh MOX fuel could be produced either by high firing the plutonium oxide and blending with uranium oxide or by a co-precipitation process. If the MOX fuel is produced by the co-precipitation process, then the Indians would not need the extra step in reprocessing this fresh fuel. If the MOX fuel is produced by the high fired process, then reprocessing this fresh fuel will require an extra step but not a difficult one, and India would have facilities capable of performing this step anyway in order to handle scrap from the MOX fabrication facility.

B. Average Burnup and Concentration of Readily Fissionable Plutonium 239 at Tarapur

The average burnup in the No. 1 Tarapur reactor has been 7,682 MWD/MT;* for the No. 2 Tarapur reactor, 9,767 MWD/MT. The expected initial burnup for the Tarapur reactor was to be 16,600 MWD/MT and the expected burnup for the reloads, 21,600 MWD/MT. The average burnup, then, has been very low compared to expectations. Moreover, even if all the fuel bundles in the No. 1 reactor received the average burnup, the plutonium in the spent fuel would be between 85 and 90% pure Pu 239, or Pu 241 (which is also readily fissionable by neutrons of all energies, and like Pu 239 and unlike Pu 240, is free of the problem of spontaneously emitting neutrons with a significant probability of pre-detonating the weapon before it has been efficiently assembled.) These are averages.

C. Unintended Variance in Burnup

Not every fuel bundle, however, would receive the average burnup and not every fuel rod within each bundle would receive the mean degree of burnup of that bundle. This would be true even if the Indians tried conscientiously to reduce the variation from bundle to bundle and from rod to rod. It would be impossible to get perfectly even burnup. There are several reasons for this. First, the action of the control rods produces some unevenness: some bundles are closer to the control rods than others, and during the operation of a reactor some control rods will be out more often than others. Second, the coolant does not flow with perfect uniformity throughout the reactor, and nuclear fissions take place more readily where it is cooler. Third, xenon instability causes power fluctuations over some parts of the reactor. As a result, there is a distribution in degrees of burnup with some fuel bundles receiving 10 or 20% less than the average.

There are also, for related reasons, variations in burnup from rod to rod in each fuel bundle. This makes it possible to remove individual fuel rods with low fuel burnup and so to obtain Pu with as little as 8% of the undesirable isotopes. Moreover, the Indians do disassemble their fuel bundles and treat individual fuel

---

* Megawatt (thermal) days per metric ton.

rods differently. In fact, the IAEA recently provided technical assistance to India in identifying the fuel rods with low burnup. The Indians replaced some of the prematurely ruptured fuel rods with some of the unruptured low-burnup rods. They could, however, also select the low-burnup rods as a source of the Pu most desirable from a weapons standpoint.

In the future, the Tarapur burnup is likely to continue to be low. The Tarapur reactors are part of an electric power grid too small to absorb their full power output simultaneously, even if both the reactors are working. What is more, electric utilities normally plan reloads conservatively, on the assumption that they will operate at rather high capacity factors and high burnup. They do this so that the reactors will not be forced to shut down because of the lack of a reload even if everything else is working. Finally, the Indians have removed some of the water from the reactors' cooling system, and this increases the steam fraction and lowers the burnup.

D. Increasing the Variance Deliberately

Until now, the variation and burnup discussed is of the sort that would take place without any deliberate attempt to increase the variability. It is plain that such unintended variation would by itself yield "weapons grade" plutonium. However, if the Indians want to have the burnup of individual fuel bundles vary greatly from the average in order to obtain low burnup fuel, they can get essentially any degree of burnup they like. They could accomplish this by moving the fuel bundles to new positions less frequently and by withdrawing bundles from the reactor sooner (perhaps due to actual or suspected rupture of the cladding). Since 97% of the fuel bundles now in spent fuel storage pools are listed as defective, and India manufactures its own fuel rods, such withdrawal may easily be justified. Take an extreme case: Since each individual bundle, even in the initial load, could theoretically be irradiated to 16,600 MWD/MT and in Tarapur 1 the average fuel burnup has been less than half that, they could give a minimal amount of irradiation to half the bundles and, to the other half, something less than double the actual average burnup. The actual average burnup would then still be well under the original projected average for the first coreload, but half the bundles would have received very little radiation. It is clear, then, that there are many intermediate cases capable of producing large quantities of relatively pure

Pu 239 and 241. Moreover, it should be understood that there is no explicit obligation on the part of the Indians to operate their reactors in the most economic fashion; no explicit obligation therefore to get maximum burnup. None of this, then would be a violation of any explicit obligation.

E. The Oversize Reprocessing Plant at Tarapur

The Tarapur reactors have only produced about 10 MTU of spent fuel a year. Under the norms usually discussed for a boiling water reactor, they should produce substantially more than that, but still only about 20 tons of spent fuel yearly. The reprocessing plant at Tarapur has a capacity of 150 MTU per year.* That is more than is necessary for recycling the spent fuel from Tarapur, even if recycling itself were economic enough to call for such recycling. And India already has a 100 MTU per year plant which is capable of reprocessing fuel from India's heavy water reactors. Assuming India's 150 MTU per year plant operates 300 days a year and that the spent fuel from the Tarapur reactors has a PU content of .4%, this reprocessing plant will be capable of producing 2 kg of PU per day. One hundred and twenty-five days of continuous operation of this 150 MTU per year plant are all that would be necessary to reprocess all of the 443 spent fuel bundles India presently possesses at the Tarapur reactor. To reprocess the 20 tons of spent fuel produced each year by the Tarapur reactors if they operated normally would take only 40 days of continuous operation by the 150 MTU per year plant. It would take half that time to reprocess the output of spent fuel at the past Tarapur rate. Pu produced by this reprocessing plant cannot be effectively safeguarded since the plutonium nitrate [$Pu(NO_3)_4$] which will be produced at the output end of the reprocessing plant will be only 5 days away from the plutonium metal which could then be directly inserted into the core of an implosion system.

F. The Economics of Recycling Tarapur Spent Fuel

The spent fuel in storage at Tarapur 1 and 2 totals 60 MTU. It contains about 240 kg. of plutonium and has an average U-235 content of 1.25%. At prices of $60/SWU** (the current U.S. price for requirements contracts) and $40 per pound U_3O_8 (at recent U.S. prices for 1980's delivery), the plutonium that could be recovered

* That figure appears in Nuclear Industry, 1970. A smaller figure of 100 MTU per year is cited in Facts on Nuclear Proliferation: a Handbook, prepared for the Committee on Government Operations, U.S. Senate, December, 1975. No source, however, is cited there. These annual figures are not well defined and are, in any case, dependent on the exact operating procedure of the plant, number of shifts, etc.

** Separative Work Unit.

from the spent fuel would be worth about $3.7 million ($15,500 per kg)*and the uranium might be worth about $16 million. The uranium value is uncertain because of the poison effects of the U-236 contained in recovered uranium. Depending on how the recovered uranium is used, its actual value might be 25 to 50% less. At these same prices, a reload of one-fourth of each core for Tarapur 1 and 2 would cost about $15 million (20 MTU of 2.4% enriched fuel, at $.73 million per MTU); thus at maximum, recovered products from Tarapur spent fuel (cumulated over 5 years) would be equivalent to about 1.3 years of reloads for these reactors.

In none of the above discussion were costs of recovering fissile products considered. Before calculating the net gain from reprocessing, these costs must be subtracted. Our analysis of the uncertain economics of reprocessing even on a large scale (1500 MTU/year) suggest that there is likely to be no positive net return on the investment in recycling. Especially at the scale of operation in Tarapur 150 MTU/yr.) recycling costs seem likely to exceed the value of recovered products.**

It would be a mistake, however, to focus unduly on whether or not reprocessing costs were less than the value of recovered products. For one thing, reprocessing even if it saved rather than lost money, could not save much in kilowatt hour generating costs; fuel cycle costs are only one-fifth of such costs and recycling <u>even if costless</u> could save at most only 30% of fuel cycle costs, i.e. 6% of the total cost. In deciding on whether to permit reprocessing of Tarapur fuel, the U.S. should consider whether, from the U.S. viewpoint, a possible economic gain <u>to India</u> compensates for the increased military risks <u>to the U.S.</u> that would result from increasing India's plutonium stockpile and from the increased difficulty this would imply in evolving a coherent U.S. policy on proliferation and safeguards. For this purpose, we wish to emphasize how small is the upper limits of potential economic gain for the five years' cost of spent fuel <u>even if reprocessing were costless</u>: $20 million, of which only $3.7 million is from recovered plutonium. In terms of nuclear weapon potential, however, the recovered plutonium could make 48 bombs (at 5 kg of plutonium per bomb).

---

* This is what the plutonium would be worth as a replacement for U235 in a LWR. The cost of recycled plutonium of course may exceed its worth. See for example Chapter IV in <u>Moving Toward Life in a Nuclear Armed Crowd?</u> Pan Heuristics report done for ACDA, February, 1976.

** An extended analysis of the economics of reprocessing in less developed countries has been done by Dr. Vincent Taylor in the course of Pan Heruistic work for ERDA and ACDA. See for example Chapter IV in <u>Moving Toward Life in a Nuclear Armed Crowd?</u> Pan Heuristics report done for ACDA, February, 1976.

G. Weapons Potential and Economics of Recycling Plutonium from Spent Heavy Water Reactor Fuel in India and Pakistan

Up to now we have talked mainly about the weapons potential and economics of separating plutonium from the spent fuel produced by the Tarapur light water reactor. It is also worth treating the Canadian designed heavy water reactor at Rajasthan and the 100 MTU per year reprocessing plant in Trombay that was designed to reprocess heavy water reactor fuel. In particular it is worth asking whether there is any serious justification other than a nuclear explosive program for reprocessing heavy water reactor fuel in India; or in Pakistan where the issue is a live one, with the Pakistanis and the French now requesting a statement from IAEA that a new French designed reprocessing plant in Pakistan could have effective safeguards. The answer should be useful in negotiations with the Canadians, with the French and perhaps with the Pakistanis.

It is sometimes argued that whatever the case for our authority to prevent the reprocessing of spent fuel from the Tarapur reactors, we could not prevent the Indians from reprocessing heavy water reactor fuel at their new Tarapur reprocessing plant, or in their reprocessing plant at Trombay. We can, however, prevent their recycling in the Tarapur reactor any plutonium from the spent fuel at Rajasthan or elsewhere, and we should be quite clear that the Indians do not have any economic need for reprocessing heavy water reactor fuel.

The Trombay reprocessing plant could reprocess all the spent fuel from about three heavy water reactors the size of Rajasthan and could separate some 200 kg. of plutonium or about 40 bombs worth per year. The Indians hardly need their new Tarapur reprocessing plant to reprocess Rajasthan fuel -- even if there were some economic point in recycling at Rajasthan.

The Rajasthan-I reactor and in fact the next 5 reactors planned by the Indians are all heavy water reactors modelled on the Canadian example. They use natural uranium fuel without enrichment. And even though there have been some ideas advanced by the Canadians for using a slight enrichment of fissile uranium or fissile plutonium to increase the burnup of fuel, recycling plutonium cannot be justified on grounds of providing energy independence. In fact the ideas for recycling plutonium in heavy water reactors like those in India and Pakistan are particularly tenuous, even more suspect than ideas for recycling plutonium as a partial substitute for enriched uranium in light water reactors. That the Indians have never seriously developed reprocessing as part of a program for economic recycling is suggested by the fact that the Trombay plant began operation in 1967, about 7 years before their first heavy water power reactor. In both the Indian and Pakistani cases, reprocessing makes sense only to derive material for nuclear explosives. In fact the Indians used Trombay to reprocess the spent fuel from the Canadian Indian research reactor to obtain the material for their nuclear explosion of May, 1974.

The Trombay reprocessing plant, like the new plant at Tarapur, could also be used to separate plutonium quickly from the unirradiated fresh mixed oxide fuel that would be found in quantity if the Indians recycle.

The Indians of course have been reprocessing spent heavy water reactor fuel at Trombay for some time, and the Pakistanis hope to do likewise. We should be quite clear that in the Pakistani case as in the Indian one, reprocessing will serve only a military purpose. In fact Prime Minister Bhutto has been more explicit about his military interest than Prime Minister Ghandi. The following explains why recycling plutonium in the CANDU reactors in India and Pakistan is unlikely to make economic sense:

a) The percentage of U-235 in CANDU spent fuel is far less than in natural uranium; thus, there is no value to the uranium that might be recovered by reprocessing.

b) The entire cost of reprocessing must be justified by the value of the recovered plutonium, but CANDU spent fuel irradiated to a typical level of 7500 MWD/MT contains only 2.7 gms of fissile plutonium per kg (compared to about 7 gms in LWR spent fuel).*

c) Because the fuel in CANDU reactors uses natural uranium and is relatively easy to fabricate, fuel costs without plutonium recycle are very low. Current fabrication costs are $35 per kg. At $28 per lb U_3O_8, fuel costs would equal $100 per kg or 2 mills/kwh; at $40 per lb U_3O_8, fuel costs would equal $139 per kg or 2.6 mills/kwh. One "model" plutonium recycling scheme involves doubling the electricity generation per kilogram of fuel. Even if this could be done

---

*All figures in this section on the CANDU were supplied by private communication from E. Critoph of Chalk River Nuclear Laboratories, Ontario, Canada. They apply to the most recently constructed CANDU reactor, Pickering IV. Figures for Rajasthan and KANUPP are likely to be less favorable.

without cost, which is far from actuality, the potential savings would be only 1 to 1.3 mills/kwh for U_3O_8 prices in the range of $28 to $40 per lb.

If the Pakistani KANUPP and Indian Rajasthan reactors operate at 50 percent of capacity (above their historical record of 45% for the most recent twelve month period) a one mill per kilowatt hour saving would translate into annual savings of $876,000 at Rajasthan (200 MW_e capacity) and $548,000 at KANUPP.

For reactors under construction, generating costs (based on recent estimates) seem likely to exceed 30 mills per kilowatt hour; thus a 1 mill savings would amount to about 3% of total generating cost. But these savings are calculated on the basis of zero extra cost to separate the plutonium and to fabricate mixed plutonium and uranium dioxide fuel. In fact, as shown below, these costs exceed the potential savings even under very favorable assumptions.

d) Canada has not yet operated even pilot plants for reprocessing of spent fuel or fabrication of mixed-oxide fuel; thus there is no realistic basis for judging likely costs. Current engineering estimates (assuming Canadian government financing) are that reprocessing CANDU fuel would cost $80 per kg and the penalty for mixed-oxide fuel fabrication would run about $35 per kg. If U.S. and Europeans experience applies to CANDU, actual costs are likely to be at least several times the initial estimates. Costs on the scale contemplated by India and Pakistan would be several times higher again.

Even using the current Canadian estimates, however, reprocessing and recycling is extremely unprofitable. In the "model" recycle program that doubles electricity generation, 5.5 gms of fissile plutonium are added to 1 kg of natural uranium. Two kgs of spent fuel (at 2.7 gms fissile Pu per kg) would need to be reprocessed to obtain this plutonium: cost at $80 per kg equals $160. Adding excess fabrication cost of $35 per kg brings the total extra cost for mixed-oxide fuel to $195. But even at a U_3O_8 price of $40 per lb, conventional CANDU fuel would cost only $139 per kg. A 100 percent increase in effectiveness at a cost penalty of 140 percent makes no economic sense. Of course, the actual economic penalty under conditions in India and Pakistan is likely to be several times as great.

Conclusion

Reprocessing and recycling of plutonium for CANDU reactors is uneconomic even under very favorable assumptions about costs and uranium prices. The upper-limit potential gains for present reactors in India and Pakistan are very small (less than 1 million per year). The technology of plutonium recycle has not been fully developed even in Canada; thus India and Pakistan would need to devote substantial scientific and engineering resources to make a recycle program operational. Given the shortage of such resources in these countries, this must be a major consideration in the decision to undertake a recycle program.

Thus, reprocessing in these countries uses scarce technical resources and promises to raise electric generating costs. From an economic viewpoint, this makes no sense. Reprocessing in these countries makes sense only as a step in the fabrication of nuclear weapons.

H. Separating Plutonium from Fresh Mixed Oxide Fuel

The problem is not simply reprocessing spent fuel. It is recycling.

Most discussion of the weapons potential in reprocessing focuses on the reprocessing of irradiated spent fuel. Some of the solutions proposed for reducing the weapons potential look forward to arrangements for taking the stocks of separated plutonium from the output end of the reprocessing plant, shipping them to a fuel fabrication facility where the plutonium in the form of plutonium dioxide would be mixed with uranium dioxide and placed in the form of pellets in fuel rods, which, in turn, would be shipped to the reactor where it would be loaded in as a replacement for one-fourth the core. Plutonium inside the reactor being irradiated, it is frequently said, is comparatively safe. While that is quite true, it ignores the more important fact that in the course of such a fuel cycle in which mixed oxides were fabricated into rods and prepared for insertion in the reactor, there would be many locations other than the reactor core where separated plutonium could be found besides the final inventories at the output end of the separation plant. For example, there would be separated plutonium at the front end and in process at the mixed oxide fuel fabrication facilities. Moreover, there would be a very large quantity of plutonium in the fresh, unirradiated fuel. In this latter condition, plutonium would require separation though it would be a simpler process than that needed for the reprocessing of the irradiated fuel. If there were no substantial separation facilities available, it would be in a condition intermediate between the separated plutonium and the plutonium in the hot irradiated fuel. So far as readiness for use in an explosive, it would be significantly different from both extremes. However, with reprocessing facilities as substantial as those in India available, there would be no significant difference in proximity to bomb manufacture between the already separated plutonium and the plutonium in the fresh, unirradiated fuel. With the Trombay and Tarapur reprocessing plants, it would take about 10 days to separate all the plutonium in fresh mixed oxide fuel manufactured from the plutonium separated from the stock of spent fuel cumulated at Tarapur sofar. This might be as much as 48 bombs worth. The reloads at the front ends of the two Tarapur reactors might contain 100 bombs worth of plutonium which could be separated at the two reprocessing plants at the rate of 5 bombs a day. Therefore, there is no point in placing hope on a policy that authorized the Indians to reprocess the spent fuel from the Tarapur reactor in their Tarapur reprocessing plant, but tried merely to limit the size of the stock of separated plutonium at the output end of that reprocessing plant. Even if that could be done effectively, it would be like punching a pillow -- large quantities of readily useable plutonium would pop up at other points in the fuel cycle. We have to face the fact that safeguards cannot be effectively applied to a fuel cycle that includes recycling of plutonium at Tarapur. No system of inspection would yield reliable and timely early warning that the plutonium was to be used in nuclear explosives.

III. Interpreting the Ambiguities in Our Favor

Our Agreement with India was drawn loosely enough, and India wanted to make it evasive and evadable enough so that no unique interpretation is possible. There is the Indian interpretation. There are many American interpretations. There is at least one defendable American interpretation consistent with the purpose of such agreements: namely to provide early warning of moves to make a nuclear explosive and to deter such moves by making clear that long before they were completed, they would be detected, reported, and adequately answered.

The Indians have resisted controls on nuclear materials steadily since the Atoms for Peace Program started in the mid-1950's. The whole 1956 debate on the safeguards provisions of the Twelve Power Draft of the IAEA statute centered on reservations interposed by India. And again the Indians were the strongest opponents of constraints in the mid-60s debate on the Non-Proliferation Treaty, which they did not join. In their bilateral arrangements with Canada and the United States, they have been less than forthcoming -- most notoriously in the case of the CIRUS reactor Agreement. They simply ignored the repeated statements by the Canadians as to the obvious meaning of the Agreement. The Indians moreover have made clear on several occasions that they recognize that the greatest possibilities for diversion occur not in reactors, but in reprocessing. Their interest in freedom to reprocess is undoubtedly informed by that recognition. One should therefore expect the Indians to construe the meaning of any agreement so as to give them the maximum of freedom.

The Indian interpretation would very likely stress that an accounting and inspection system is an "effective application" of safeguards, whether or not the audit is timely, and even if it were a post-mortem made long after the event. (In fact some American officials, temporarily losing sight of the point of it all, said much the same a half dozen years ago.) The Indians could also say that reprocessing was certainly not precluded, that in fact it was contemplated and actually mentioned in the Agreement and that the only requirement was that there be adequate safeguards and specifically that the facility be safeguardable. (In the mid-1960s, some plans for "safeguarding" separation plants were advanced with no serious consideration as to whether safeguards could be effectively applied.)

The Indians might further stress that even the clause stating that the fuel provided for Tarapur and its products could be used only in Tarapur was vitiated by Clause 9 of Article VI which says in effect that whatever else the agreement says, the Indians have the right to remove special nuclear material from the scope of the agreement provided they have placed agreed equivalent quantities "of the same type" of material under its scope. They might argue then that they could take some of the separated plutonium and use it elsewhere, provided they replaced it with an equivalent amount of plutonium, possible even unseparated plutonium or plutonium of different isotopic composition. (The phrase "of the same type" is unclear.) Finally the Indians will argue, as they have, that the plutonium they use in nuclear explosives is peaceful. The agreement does not explicitly close off a PNE loophole.

The consequences of accepting even some parts of the Indian unilateral interpretation should be very clear from the analysis in Part II: the Indians would be able to derive large stocks of Pu 239 of any degree of purity they want and separate it in the form of plutonium nitrate (which is 5 days away from the metal, and insertion in the core of a bomb). They could, in fact, legally put it in the form of metal itself. If one accepts all of the Indian interpretation, including the PNE loophole, they can insert the metal in implosion systems and explode them.

Among other things accepting the Indian construction of the agreement would make completely empty all the claims we regularly put forward for the virtues of light water reactors (LWRs), compared to the Canadian heavy water reactors (HWRs): a) The Indians have demonstrated that they can without objection operate their reactors so irregularly and with such a low capacity factor that diversion is no more difficult than in an HWR, b) the degree of burnup has been so varied that operation to obtain "weapons grade" plutonium cannot be distinguished as a departure from their "pattern" of operation for electric power, and c) the argument that the HWR produces more plutonium per megawatt day, that is per unit of electrical output, has never been a strong one, and it ignores the fact that the heavy water reactor's plutonium is more dilute, that the HWRs produce roughly only one half to one third as much plutonium per tonne. In fact the cost of separating the plutonium from the HWR is <u>more</u> than triple the cost of separating it from the LWR's fuel, since the LWR fuel also yields some recoverable uranium as a partial offset to the cost of reprocessing. The HWR on the other hand reduces the U235 content of its natural uranium fuel to about .15%, which is lower than our tails assays when we enrich uranium. There is no enriched uranium to recover in the chemical reprocessing of HWR fuel. Finally, d) accepting India's interpretation weakens the remaining argument that we have offered for LWRs compared to HWRs: that the LWR need for enriched fuel gives us a sanction and a control. But our behavior with respect to the Indian nuclear test and since suggests that we are unwilling to use that sanction and indeed could not if we accept the Indian interpretation.

The Indian interpretation would not only demolish our claims for the safety of the LWR; if accepted, it would destroy any basis for restraining the spread of nuclear weapons technology through such agreements. We need to insist on and enforce our own interpretation where we can, I would say, not only with respect to Indian reprocessing but with respect to all agreements that have not explicitly plugged the PNE loophole. A good many governments in addition to India blandly adopt the position that nuclear explosives are peaceful and that therefore using plutonium from a civilian reactor to make such explosives is also a peaceful activity. Some American officials feel somehow bound even by such a plainly evasive unilateral interpretation of nuclear cooperation agreements as that taking nuclear explosives as non-military. (Some have solemnly avowed that the Indians did not violate their agreement with the Canadians -- as if there were not even an ambiguity.) However, we said clearly at least as early as 1966 in the ENDC debates that <u>any</u> nuclear explosive was a military weapon and so did the Canadians. Moreover we have said that in private to the Indians. The fact that the Indians have not said they accept that obvious interpretation and the fact that some other governments simply note our statements on the subject now does not mean that we should not enforce, wherever we have the leverage to do so, <u>our</u> interpretation.

In my view, looking at it country by country, we do have a good deal of leverage. In the Indian case, quite apart from the enrichment services that we might withhold or the more drastic measures we might conceivably insist on (including the return of equipment) there are some quite effective things we could withhold now. The Indians have a good deal of trouble keeping their boiling water reactors at Tarapur operating even half the time. They have a continuing flow of help from G.E. for that purpose. We are certainly able to stop that flow and to stop also the flow of replacement components, etc. We can also refuse to license reloads for Tarapur.

A good many Americans are troubled and prevented from acting forcefully by the thought that our agreements on cooperation here and elsewhere are ambiguous. They are in the habit of saying, "The Indians could always argue that . . . ." Indeed they could and do. I am myself not troubled by that possibility, in part because I have never heard an Indian given much pause by the possibility that "The Americans could always argue that . . . ."

We have excellent grounds in common sense and in the history of the development of safeguards for interpreting the phrase "effective application of safeguards" in the agreement in our favor, and we should do that.

Throughout the history of safeguards since the end of World War II, it has always been understood that their essence involved at least the provision of early warning, that is, warning timely enough for either international response or appropriate national response forestalling the manufacture of nuclear explosives or cancelling their effects. Some believed that arrangements for international sanctions exploiting such warning were also needed. Others held that warning was enough. But explicitly or implicitly, early warning has always been understood as essential.

The early interest in "denaturing" fissile material was dictated by the desire to extend the "critical time" to make a nuclear explosive by diluting materials with undesirable isotopes so that isotopic, not merely chemical, separation would become necessary. The Acheson-Lilienthal Report reflected the hope that two or three years of warning could be achieved by this device. Even earlier, the need for warning measured in years was advocated by Leo Szilard in essays that suggested denaturing and that formed some of the background for the early attempts at international control:

> A system of controls could be considered successful only if we could count on a period of grace in case the controls were denounced or obstructed by one of the major powers. This means that the system would have to be of such a nature that at least one or two years would elapse between the time the nations begin to convert their installations toward the purpose of manufacturing atomic bombs, and the time such bombs become available in quantity.
>
> Unpublished version of "Atomic Bombs and the Post-War Position of the United States in the World," March, 1945, available in the office of the ERDA historian, excerpted in the Bulletin of the Atomic Scientists, December, 1947.

The hopes for a denaturing that would compel isotopic separation were disappointed. However, chemical separation has remained as a barrier that takes a substantial, if lesser, amount of time to surmount. Any interpretation of safeguards that removes this last barrier of chemical separation and leaves practically no warning time should be recognized as abandoning the essential purpose of safeguards.

If the critical time to make an explosive is allowed to shrink to a few weeks, days or hours, there will not be enough time for political or military action. For one thing, deciding on appropriate political or military responses would take time, and political responses in themselves might be very time consuming. For another, the warning would not begin with the moment of diversion. The first indication of violation an inspector might have, even if he were on the scene, might be some denial of access, and this would be only the beginning of a long sequence of events, restricted at first to the Indians and the inspector. It would take a considerable amount of evidence before an inspector would be willing to send a report of violations to the IAEA Board. He cannot himself notify the member countries involved. His report would then have to go through channels to the Inspector General of IAEA, and according to the current Inspector General's estimate,* the time involved in transmission through channels is approximately six months.

Both the IAEA and the U.S. government have reiterated the essential point, that the purpose of safeguards (and therefore the objective that would have to be achieved for the application of safeguards to be "effective") is to assure early detection and the deterrence of diversion through the risk of early detection. The President made that point last May in his Report to the Congress on Nuclear Exports and Safeguards. General Starbird's testimony last month asserted that "IAEA safeguards provide for the timely detection of diversion of significant quantities of nuclear materials from peaceful nuclear activities and the deterrence thereby of such diversion by threat of early detection." (Statement before the Senate Committee on Government Operations, January 29, 1976) That assertion faithfully reproduces the objective of safeguards as clearly defined by the IAEA Safeguards Committee: "the timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or of other nuclear explosive devices or for purposes unknown, and deterrence of such diversion by the risk of early detection." (See IAEA INFCIRC/153 (1971) and B. Sanders and R. Rometsch, "Safeguards Against Use of Nuclear Materials for Weapons," September, 1975, Nuclear Engineering International, p. 683.)

---

* Reported at a meeting of the California Seminar on Arms Control and Foreign Policy, November 6, 1975.

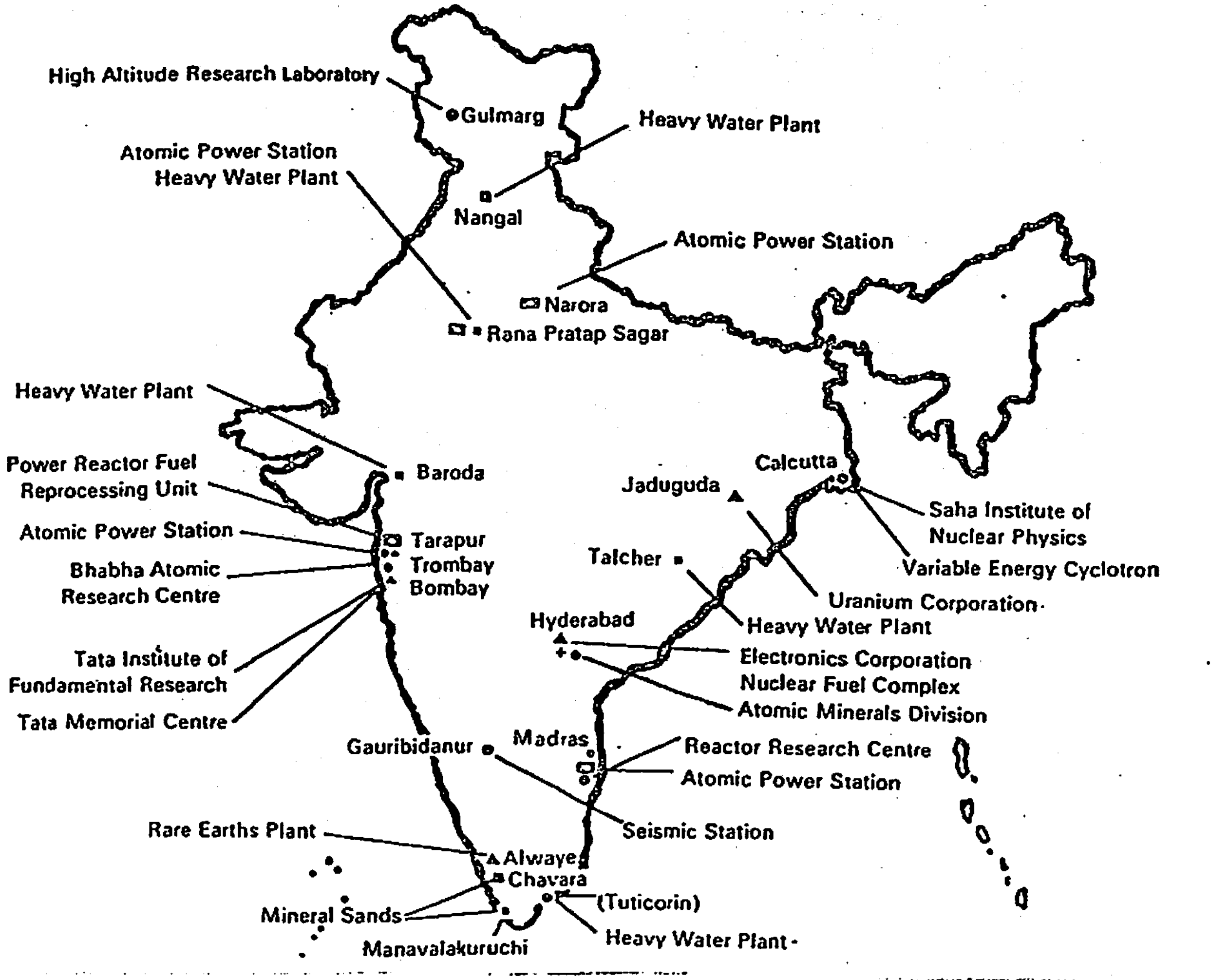
The point of it all may have been lost sometimes in the middle and lower regions of various national and international bureaucracies. But as the Inspector General of IAEA suggests, "The thirty years history of safeguards is one of continuous development and there is no reason why its techniques and concepts should not undergo many further changes." (Ibid) And there is every reason that further evolution should clarify and make more precise the tailoring of safeguards to their essential purpose.

We can in any case make clear that the United States interprets safeguards in this way and that therefore they cannot be effectively applied to recycling in India. Moreover if we formulate our inquiry carefully to the Inspector General of IAEA as to whether safeguards can be effectively applied to Tarapur -- specifying that we mean, as he has meant, assuring that the entire process of detection, evaluation, reporting to the Board, decision by the Board, notification of member states and reasonable prudent response by the member states can be completed before explosives are assembled -- we should be able to get the agreement of the Inspector General.

Finally, let us reply to one recurring argument: We cannot do this now, because we failed to do it earlier. To accept such an argument would make any mistake, no matter how disastrous, hereditary. We should not feel self-conscious about the fact that we have not always enforced our own interpretation in the past. Since it makes sense, we should do so now.

Addendum I From the Annual Report of the Department of Atomic Energy, 1974-1975 of the Government of India

ATOMIC ENERGY ESTABLISHMENTS



ATOMIC ENERGY ESTABLISHMENTS IN INDIA

The BHABHA ATOMIC RESEARCH CENTRE, Trombay, which was set up as the Atomic Energy Establishment in 1957 and renamed in 1967, is the national centre for research and development work in nuclear energy and related disciplines. Its facilities include four research reactors, namely, CIRUS (40 MW), Apsara (1 MW), ZERLINA (a zero energy thermal reactor) and PURNIMA (a zero energy fast reactor), a 5.5 MeV Van-de-Graaff accelerator, a H-400 computer, a BESM-6 computer, and various special laboratories. It also has a uranium metal plant, a fuel elements fabrication plant, a plutonium plant etc.

The REACTOR RESEARCH CENTRE is being set up at Kalpakkam, Tamil Nadu, adjacent to the Madras Atomic Power Station. The most important facility in this Centre will be the Fast Breeder Test Reactor which will provide experience in the design, construction and operation of a plutonium-fuelled, sodium-cooled fast reactor. It will also serve as an irradiation facility which is essential for developing fuel for the large fast breeder reactors of the future. The other facilities at the Reactor Research Centre will help in the construction and operation of the Fast Breeder Test Reactor and use of the test reactor for studies in connection with future fast breeders.

The GAURIBIDANUR SEISMIC STATION (of the Bhabha Atomic Research Centre), 80 kilometres north of Bangalore, was set up towards the end of 1965 in collaboration with the U.K. Atomic Energy Authority. It has a full array of 20 sensors deployed over an area of 25 km x 25 km. It helps in the detection and identification of underground nuclear explosions and also facilitates seismic research.

HEAVY WATER PLANTS

The NANGAL HEAVY WATER PLANT in the Punjab, operated in conjunction with the Nangal Plant of the Fertilizers Corporation of India, was commissioned in August 1962. It has an annual capacity of about 14 tonnes.

The KOTA PLANT being built by the Department of Atomic Energy next to the Rajasthan Atomic Power Station will produce about 100 tonnes of heavy water a year. The plant is based on the know-how generated by BARC.

The BARODA PLANT based on the Ammonia hydrogen exchange process developed by a French consortium, will be linked to the synthesis gas stream of the Fertilizer Plant at Baroda of the Gujarat Fertilizer Corporation. Its capacity is expected to be 67.2 tonnes a year.

The TUTICORIN PLANT will be similar to the Baroda Plant and will be linked to the fertilizer plant of the Southern Petrochemical Industries Corporation. Its capacity will be 71.3 tonnes per year.

The TALCHER PLANT, equipment and knowhow for which are being obtained from a West German firm, will use the synthesis gas stream of the Ammonia Plant being set up at Talcher by the Fertilizer Corporation of India. It will produce 62.7 tonnes of heavy water a year.

The NUCLEAR FUEL COMPLEX in Hyderabad which is designed to meet the fuel requirements of nuclear power reactors consists of the following:

1. Zirconium Oxide Plant
2. Zirconium Sponge Plant
3. Zircaloy Fabrication Plant
4. Uranium Oxide Plant
5. Ceramic Fuel Fabrication Plant
6. Enriched Uranium Oxide Plant
7. Enriched Fuel Fabrication Plant
8. Special Materials Plant

Two more plants — an alloy Steel Seamless Tube Plant and a Titanium Pilot Plant — are also being set up in the Complex.

The POWER REACTOR FUEL REPROCESSING PLANT, Tarapur, which is nearing completion, is being built by the Bhabha Atomic Research Centre using the experience gained with the designing, construction and operation of the Trombay Plutonium Plant. This plant will process the irradiated fuel from the Tarapur and Rana Pratap Sagar power reactors.

The VARIABLE ENERGY CYCLOTRON, Calcutta, is being erected in the Salt Lake Township area near Calcutta by the Bhabha Atomic Research Centre. It will be a national facility for advanced work in nuclear physics and for the controlled direct irradiation of biological and agricultural products.

The HIGH ALTITUDE RESEARCH LABORATORY, Gulmarg, which was set up by the Department of Atomic Energy in 1963, provides facilities for high altitude research to all scientific institutions and universities in the country.

The ATOMIC MINERALS DIVISION is responsible for surveying, prospecting and exploratory development of atomic minerals required for the atomic energy programme. It carries out various types of surveys such as airborne, jeep, ground and offshore submarine surveys. These field activities are supported by well-equipped petrology, minerals, technology, chemistry and physics laboratories which not only provide the necessary aid by way of study and analysis of samples but also are responsible for the development of new instrumentation and methods.

The TARAPUR ATOMIC POWER STATION, 100 kilometres north of Bombay, is the first atomic power station in India. It has two Boiling Water type reactors fuelled by enriched uranium, with a total output of 400 MWe of electricity which is supplied to the States of Maharashtra and Gujarat.

The POWER PROJECTS ENGINEERING DIVISION undertakes the design, construction and commissioning of nuclear power plants. It is presently engaged in building the second unit of the Rajasthan Atomic Power Project, and the Madras Atomic Power Project. It has also taken up work on the fourth atomic power station at Narora.

The RAJASTHAN ATOMIC POWER STATION at Rana Pratap Sagar in the State of Rajasthan is under construction. It will have two natural uranium-fuelled and heavy water moderated Candu-type reactors (one already operative) with a total net output of 400 MWe of electricity. The first reactor is delivering power to the Northern Grid.

The MADRAS ATOMIC POWER STATION about 80 kilometres south of Madras, will be the third atomic power station in India and will have two Candu-type reactors similar to the Rajasthan ones. It will be indigenous to the extent of about 80 per cent. There is no foreign collaboration in its design or construction.

The NARORA ATOMIC POWER STATION U.P., will consist of two units of 220 MWe each of a modified design.

The INDIAN RARE EARTHS LTD. is a Government of India company functioning since 1950 and operates the mineral sands industry in Manavalakurichi and Chavara, and the rare earths industry at Alwaye. It also produces thorium products at Trombay on behalf of the Government.

The URANIUM CORPORATION OF INDIA LTD., Jaduguda, was formed in October 1967. It is responsible for the development of the Uranium Mine and operation of the Uranium Mill at Jaduguda.

The ELECTRONICS CORPORATION OF INDIA LTD., Hyderabad, was formed in April 1967 and gradually took over the work of the Electronics Production Unit of the Bhabha Atomic Research Centre. It produces on a commercial scale a large variety of nuclear instruments, control equipment, electronics components etc. developed by the Bhabha Atomic Research Centre and the Tata Institute of Fundamental, Research.

The TATA INSTITUTE OF FUNDAMENTAL RESEARCH, Bombay, was founded in June 1945. It is the national centre of the Government of India for Nuclear Science and Mathematics. It has two schools: the School of Mathematics and the School of Physics (Experimental Physics, Theoretical Physics, Astrophysics, Geophysics, Computer Science, Molecular Biology and Radio Astronomy). Its special facilities include a National Computation Centre (with a CDC 3600-160A computer system), a Balloon Fabrication and Flying Facility (at Hyderabad), Tritium Laboratory for Hydrological Studies, an Electron Microscope, a 1 MeV Cascade Generator, a 3.5 MeV Electron Linear Accelerator, X-ray Units, an Electromagnetic Mass Separator and Liquid Nitrogen and Liquid Helium Plants.

The TATA MEMORIAL CENTRE, Bombay, comprises two institutions: The Tata Memorial Hospital and the Cancer Research Institute. In addition to being one of the foremost cancer treatment centres in the country, it also conducts extensive research on cancer.

The SAHA INSTITUTE OF NUCLEAR PHYSICS, Calcutta, was formally opened in June 1950. Its fields of research include: electron microscopy, EPR spectroscopy, mass spectrometry, microwave absorption spectroscopy, molecular biology, NMR spectroscopy, NQR spectroscopy, nuclear activation, nuclear reactions, nuclear spectroscopy, radiochemistry, solid state physics, structural crystallography, technical physics and theoretical nuclear physics.

NUCLEAR ENGINEERING INTERNATIONAL: March, 1977, Vol. 22 No. 354 p.60-61.

INDIA

RAJASTHAN ATOMIC POWER STATION (RAPS) 2

220 MWe CANDU-PHW AECL
India Department of Atomic Energy
Construction start: December 1967
Commercial operation: 1978

Nuclear and conventional erection activities have nearly been completed and commissioning of the various system are in full swing.

All jobs on fuelling machines, reactivity mechanism, feeder and header insulation cabinets have been completed. Additional piping works like new compressed air/chilled water plant, 23 and 15 per cent D_2O storage facility, etc. are in progress.

Erection of motor generator sets has been completed and commissioning is in progress. Instrumentation work on various systems has almost been completed. Erection and testing of a steam line to the Heavy Water Project, Kota, is nearing completion.

Civil work for warehouse No. 3, compressed air/chilled water plant and spent fuel bay (extension) has been completed and that for permanent guard house, extension of covered passage and road on east of R.B. 2 is in progress. Civil works on the Solar Evaporation facility and domestic water supply works are under way.

MADRAS ATOMIC POWER STATION 1

235 MWe PHWR IDAE
Indian Department of Atomic Energy
Construction start: May 1969
Commercial operation: 1979

All major structures of both the units including upgrading plant and stack except main airlock barrels and closing of break out panels have been completed.

Major reactor equipment, e.g. end shields, calandria and dump tank, have been installed and aligned. Installation of the shield tank is nearing completion. Balance activities of the coolant channel installation, feeders and fuelling machine access doors are in progress. Most of the major system equipment have been installed. 40 per cent of reactor building piping and 75 per cent of conventional piping have been completed.

Alignment of HP turbine, LP turbine and generator rotors have been completed and machine boxed up. TG systems piping, arrangements for testing of TG with auxiliary boiler, and condenser tubing are in progress.

Ventilation systems for Turbine and Service Building have been finished and that for the Reactor Building is in an advanced stage of completion. Two circulating water pumps, and all travelling water screens have been installed. Performance testing of CW pump and 543 tonne centrifugal chiller is in progress. Installation of main plant electrical equipment, cabling and lighting has been completed. The 230 kV indoor switchyard has been energised and 6.6 kV supply has been made available.

D.N. monitoring tubing, control room instrumentation and other main plant instrumentation work have been initiated.

MADRAS ATOMIC POWER STATION 2

235 MWe PHWR IDAE
Indian Department of Atomic Energy
Construction start: May 1970
Commercial operation: 1980

All civil works except for the purification plant, main airlock barrel and closure of break out panels have been completed. The calandria is in an advanced stage of completion and the end shield manufacture is in progress.

Manufacture of primary heat transport pumps is also nearing completion. In the calandria vault, liner and thermal shield installation are in progress. End shield rings have been installed and grouting is in progress. A 25t boiler room crane has been installed. Main plant piping, turbine and condenser installations have been initiated.

NARORA ATOMIC POWER PROJECT

2×235 MWe PHWR IDAE
Indian Department of Atomic Energy
Construction start: March 1976 (unit 1); January 1977 (2)
Commercial operation: March 1982 (unit 1); March 1983 (2)

Detailed designs in nuclear and conventional areas have progressed substantially. Decision was taken on the type of the steam generator and the condenser cooling water systems and detailed designs in these areas are in progress.

A computer programme for the dynamic stability of the unit on the UP State Electricity Board grid system has been made and preliminary studies completed. Reactor containment and internal civil structure designs have substantially progressed. Preliminary loading diagrams for the containment and internal structure including vent shafts and distribution headers have been finalised. Design of the liquid shut off system has been finalised.

Development works on welding of end fittings to calandria, end fitting seal bellows, end shield diaphragm stress analysis and end shield ball fitting are in progress. Design basis of the plant cooling water and ventilation systems have been finalised.

Procurement action for the moderator heat exchangers, tubes for various reactor auxiliary heat exchangers, feed water heat plant, secondary cycle pumps, start-up and unit transformers has been initiated. Purchase orders for the manufacture of calandria, imported carbon steel pipes for PHT system, imported material for reactor headers have been placed.

Manufacture of the end shields and primary heat transport pumps are in progress. Billets for the manufacture of Unit-1 end fittings have been received and are under further process to manufacture the end fitting forgings.

Purchase recommendations for the generator transformer, process water pumps for potentially active loops, turbine building crane, have been finalised. Manufacture of the turbo-generator is in progress.

At site, construction facilities such as warehouses, office building, garage, roads and communication facilities have been established.

Works on the main plant buildings, e.g. Reactor, Turbine and Service Buildings, have started. Excavation work for Reactor Building of Unit No. 1 has been completed while that for Turbine & Service Building is in progress. Concreting of the raft of the Reactor Building is in progress.

Extensive testing for piling work in the Turbine Building has been completed. Regular foundation work on the Turbine Building is in progress. Refrigeration, batching and crushing plants have been commissioned.

Site fabrication workshop has been commissioned and fabrication of the embedded parts has been taken up. Work on construction of a power supply from the State Electricity Board was completed. Two emergency diesel sets have been erected.

BIBLIOGRAPHY

Books

Anderson, Robert S., Building Scientific Institutions in India: Saha and Bhabha, Occasional Paper Series No. 11, Centre for Developing-Area Studies, McGill University, Montreal, 1975.

Barnds, William J., India, Pakistan, and the Great Powers, New York: Praeger Publishers, 1972.

Bauer, P.T., Indian Economic Policy and Development. New York: Frederick A. Praeger, 1961.

Berkes, Ross N. and Mohinder S. Bedi, The Diplomacy of India, Stanford, California: Stanford University Press, 1958.

Bowles, Chester, A View from New Delhi, Selected Speeches and Writings, 1963-1969. Bombay, India: Allied Publishers, 1969.

Canada. House of Commons Debates. Volume IX, 1964, Volume III, 1971. Ottawa, Canada: Queen's Printer, Information Canada.

Gupta, Hari Ram, India-Pakistan War 1965, Volume II. Delhi-26, India: Hariyana Prakashan, 1968.

Hoehn, William E., The Economics of Nuclear Reactors for Power and Desalting, RM-5227-1-PR/ISA. Santa Monica, California: The Rand Corporation, November, 1967.

Henderson, P.D., India: The Energy Sector. Washington, D.C.: The Inter-National Bank for Reconstruction and Development, 1975.

India. Central Electricity Authority. Third Annual Electric Power Survey of India. India: CEA, May, 1965.

India. Report of the Energy Survey of India Committee. New Delhi, India: Published by Government of India, 1965.

India. Government of India. LOK SABHA Debates. "Production of Plutonium in Atomic Power Plants," Bhadra 4, 1892 (SAKA) August 26, 1970.

India. Government of India. Nuclear Explosions and Their Effects. The Publications Division, New Delhi, Revised ed. October, 1958.

India. Government of India. Annual Report of the Department of Atomic Energy, 1974-1975. New Delhi, India: Government of India Press, 1975.

India. Government of India. Economic Survey, 1974-75. New Delhi, India: Government of India Press, 1976.

India. The Institute for Defence Studies and Analyses, New Delhi, India. A Strategy for India for a Credible Posture Against A Nuclear Adversary. New Delhi, India: IDS&A, 1968.

International Atomic Energy Agency, Vienna. IAEA Infcirc/153, The Structure and Content of Agreements Between the Agency and States Required in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons. Vienna, Austria: IAEA, 1971.

International Atomic Energy Agency, Infcirc/211, The Text of a Safeguards Agreement between the Agency, Canada, and India, Vienna, Austria: IAEA, November 6, 1974.

International Atomic Energy Agency, Vienna. IAEA/CS/OR7, OR37,28. Conference on the Statute of the IAEA, UN Headquarters 1956 verbatim.

Johnson, William A., The Steel Industry of India. Cambridge, Massachusetts: Harvard University Press, 1966.

Marwah, Onkar Singh, India: Conflict System, Security Environment, and Policymaking for Defense. Berkeley, California: Ph.D. thesis, University of California, 1976.

Mullenbach, Philip, Civilian Nuclear Power: Economic Issues and Policy Formation. New York: The Twentieth Century Fund, 1963.

Nehru, Jawaharlal, India's Foreign Policy. Publications Division, Ministry of Information and Broadcasting, Government of India, New Delhi, 1961.

Nyrop, Richard F., B.L. Benderly, W.W. Cover, M.J. Cutter and N.B. Parker. Area Handbook for India, 3rd edition. American University Foreign Area Studies, DA Pam 550-21. Washington, D.C.: U.S.G.P.O., 1975.

Palmer, Norman D., The Indian Political System. Boston, Massachusetts: Houghton Mifflin Co., 1971.

Patil, R.L.M., India: Nuclear Weapons and International Politics, Delhi, India: National Publishing House, 1969.

Radhakrishnan, Sarvepalli and Charles A. Moore, Editors. A Sourcebook in Indian Philosophy. Princeton, N.J.: Princeton University Press, 1957. Pp. 280-284, "The Theory of No-Soul or Self."

Speier, Richard H., United States Strategies Against the Proliferation of Mass Destruction Weapons. Ph.D. Thesis, Massachusetts Institute of Technology, March 1968.

United Nations. Eighteen Nation Disarmament Committee Debates, 1960-67 passim. ENDC/PV series.

U.S. Congress. House of Representatives. Subcommittee on Energy and the Environment of the Committee on Interior and Insular Affairs, Oversight Hearings on Nuclear Energy-International Proliferation of Nuclear Technology. Parts I, II, III. Washington, D.C., 1975.

U.S. Congress. House of Representatives. Committee on Foreign Affairs, Hearings on U.S. Foreign Policy and the Export of Nuclear Technology to the Middle East before the subcommittees on International Organizations and Movements and on the Near East and South Asia, June 25; July 9, 18; and September 16, 1974. USGPO, Washington, D.C., 1974.

U.S. Congress. House of Representatives. Committee on International Relations, Nuclear Proliferation: Future U.S. Foreign Policy Implications, hearings before the Subcommittee on International Security and Scientific Affairs. Ninety-Fourth Congress, first session, October 21, 23, 28, 30; November 4 and 5, 1975. Washington, D.C.: USGPO, 1975.

U.S. Congress, House of Representatives. Hearings on Extension of the Export Administration Act of 1969, Part I, June and August 1976, Washington, D.C.: USGPO, 1976.

U.S. Congress. Joint Committee on Atomic Energy. Hearing on S. 1439: Export Reorganization Act of 1976, June 22, 1976. Washington, D.C.: USGPO, 1976.

U.S. Congress. Joint Committee on Atomic Energy. Report of the Raw Materials Subcommittee on Its Visit to Australia, February 9, 1955. Washington, D.C.: USGPO, 1955.

U.S. Congress. Senate Committee on Government Operations. Hearing on S. 1439: The Export Reorganization Act--1975, April 24, 30 and May 1, 1975. Washington, D.C.: USGPO, 1975. Also, Hearing on S-1439, January and March 1976. Washington, D.C.: USGPO, 1976.

U.S. Congress. Senate Subcommittee on International Finance of the Senate Banking, Housing and Urban Affairs Committee. Exports of Nuclear Materials and Technology; Hearings, July 12, 1975. Washington, D.C.: USGPO, 1975.

U.S. Library of Congress. The Congressional Research Service for the U.S. Senate Committee on Government Operations. Nuclear Weapons Proliferation and The International Atomic Energy Agency, March 1976. Washington, D.C.: USGPO, 1976.

U.S. Department of State Agency for International Development, India: Tarapur Nuclear Power Project (AID-DLC/P-170), June 1963. Mimeo in AID Office.

U.S. Department of the Army #550-21. U.S. Army Area Handbook for India. Washington, D.C.: USGPO, July 1974.

U.S. and India. Atomic Energy; Cooperation for Civil Uses, Agreement signed at Washington, August 8, 1963. U.S. Department State, Series 5446.

U.S.-India Cooperation Agreement. Atomic Energy; Application of Safeguards by the IAEA, signed at Vienna, January 27, 1971. U.S. Department of State, Series 7049.

U.S. Joint Committee on Atomic Energy. International Agreements for Cooperation. Hearings before the Subcommittee on Agreements for Cooperation, September 5, 1963 and April 22 and June 30, 1964. Washington, D.C.: USGPO, 1965. Also, April 29, June 4, and July 13 and 27, 1965, USGPO, 1965; January 27, May 26, June 28, August 25, 1966, USGPO, 1966; March 20, 1967 and June 25, 1968, USGPO, 1968.

U.S. Nuclear Regulatory Commission. NRC Tarapur Export License Hearing, March 1976; typescript.

U.S. Nuclear Regulatory Commission. NRC Decision on Tarapur, March 26, 1976. In the Matter of Edlow International Company as Agent for the Government of India, to Export Special Nuclear Material before the U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

U.S. Nuclear Regulatory Commission, NRC Staff Comments on Proposed Export of Special Nuclear Material to India (License No. XSNM-845), July 8, 1976, typescript.

U.S. Nuclear Regulatory Commission. In the Matter of Edlow International Company, Department of State Responses to Questions as Requested in Commission's Order of July 19, 1976; Typescript.

U.S. Nuclear Regulatory Commission. Hearings on the Matter of Edlow International Company, July 20 and 21, 1976. Washington, D.C. Typescript.

Vernon, Raymond. Sovereignty at Bay. New York: Basic Books, 1971.

U.S. Energy Research and Development Administration. U.S. Nuclear Power Export Activities, Vol. I of Final Environmental Statement, April 1976. ERDA 1542- [illegible] UC-2.

Articles

Beckhofer, Bernard G. and Eric Stein. "Atoms for Peace," Michigan Law Review, Vol. 55, 1957.

Bhabha H.J., "The Role of Atomic Power in India and Its Immediate Possibilities," Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, Geneva, August, 1955, Volume I, Also Volume XVI, Record of the Opening Session and Closing Remarks, New York: United Nations, 1956.

_____, "On the Economics of Atomic Power Development in India and the Indian Atomic Energy Programme," evening lecture of September 6, 1957, The Advancement of Science, Vol. XIV, No. 55. London: The British Association for the Advancement of Science, December 1957.

_____, "The Need for Atomic Energy in the Under-developed Countries," Proceedings of the Second United Nations International Conference on the Peaceful Uses of Atomic Energy, Geneva, September 1958, Volume I, Geneva: United Nations, 1958.

_____, "The Implications of a Wider Dispersal of Military Power for World Security and the Problem of Safeguards," 12th Pugwash Conference, January-February, 1964.

_____, "Science and Problems of Development," Science, Feburary 4, 1966.

_____, and M. Dayal, "World Energy Requirements and the Economics of Nuclear Power with Special Reference to Underdeveloped Countries," from Proceedings Third International Conference of Peaceful Uses of Atomic Energy, Geneva, August 31-September 9, 1964, Volume 7, New York: United Nations, 1965.

_____ and N.B. Prasad, "A Study of the Contribution of Atomic Energy to a Power Programme in India," Proceedings of the Second United Nations International Conference on the Peaceful Uses of Atomic Energy, Geneva, September, 1958. Volume 1, Geneva: United Nations, 1958.

Bhargava, G.S., "India's Security in the 1980's," Adelphi Paper #125, London: The Institute for Strategic Studies, Summer, 1976.

Braun, Dieter, "Implications of India's Nuclear Policy for the Region," The Persian Gulf and Indian Ocean in International Politics, edited by Abbas Amirie, Tehran, Iran: Institute for International Political and Economic Studies, 1975.

Chandrasekhara, Rao, R.V.R., "Proliferation and the Indian Test: A View from India," Survival, Volume XVI, Number 5, September/October 1974.

Cockcroft, Sir John, "Homi Jehangir Bhabha, 1909-1966," Proceedings of the Royal Institution, Volume 41, Part IV, number 191. 1967.

Dayal, M., "Integration of Nuclear Power Stations in Power Networks with Special Reference to Developing Countries," Proceedings of the Third International Conference on Peaceful Uses of Atomic Energy, Geneva, 31 August- 9 September, 1964, Volume 1, Progress in Atomic Energy, New York: United Nations, 1965.

Desai, M.J., "India and Nuclear Weapons," Arms Control and Disarmament, Volume 3, Number 2, Autumn 1965.

Dunn, Lewis A. "India, Pakistan, Iran. . . A Nuclear Proliferation Chain?" prepared for the 28th Annual Meeting of the Association for Asian Studies, Toronto, Canada, March 19-21, 1976, New York: Hudson Institute, (HI-2407-P), 1976.

Ghaswala, S.J., "Bombay, India's Peaceful Atomic Program Reacts to Chinese Bomb," International Science and Technology, February 1965, No. 38.

Gilinsky, Victor, Commissioner, U.S. Nuclear Regulatory Commission, Statement of...before the Government Operations Committee, January 29, 1976, Typescript.

Gillette, Robert, "India: Into the Nuclear Club on Canada's Shoulders," Science, Vol. 184, No. 4141, pp. 1053-1055, June 1974.

Greene, Fred, "The Indian-Pakistan War and the Asian Power Balance," Naval War College Review, January-February 1973.

Gupta, Sisir, "Break With the Past," Seminar, New Delhi, January 1965. Special issue on the Bomb.

Jacobs, Paul, "What You Don't Know May Hurt You," Mother Jones, February/March, 1976.

Kapur, Ashok, "India's Nuclear Presence," The World Today, November 1974.

Kissinger, Henry, "Toward a Global Community: the Common Cause of India and America," speech before the Indian Council on World Affairs, New Delhi, India, U.S. Department of State, Bureau of Public Affairs, PR445, October 28, 1974.

______, "Maintaining the Momentum Toward Peace," address before the 29th Session of the U.N. General Assembly, New York, September 23, 1974, PR373, U.S. Department of State, Bureau of Public Affairs.

_____, "The Global Challenge and International Cooperation," speech before the Institute of World Affairs, University of Wisconsin, July 14, 1975, U.S. Department of State, Bureau of Public Affairs, PR370.

Kothari, Rajni, "Sources of Conflict in the 1980's," Typescript of paper presented at the Conference, Proliferation of Force and the Diffusion of Power, Vienna: International Institute for Strategic Studies September 9, 1976.

Krishna, Raj, "India and the Bomb," India Quarterly, Volume 21, April-June 1965.

_____, "Proliferation," India Quarterly, Volume 22, Number 3, July-September, 1966.

Little, I.M.D., "Atomic Bombay? A Comment on 'The Need for Atomic Energy in the Underdeveloped Countries,'" The Economic Weekly, Bombay, India, November 29, 1958.

Lukas, J. Anthony, "India is as Indira Does," New York Times Magazine, April 4, 1976.

Maddox, John, "Prospects for Nuclear Proliferation," Adelphi Papers No. 113 London, England: The International Institute for Strategic Studies, spring, 1975.

McElheny, Victor K., "Electric Power Remains Emphasis of India's Nuclear Energy Program," Science, Volume 149, 16 July 1965, pp. 284-287.

Menon, M.G.K. "Homi Jehangir Bhabha, 1909-1966," Proceedings of the Royal Institution, Volume 41, Part IV, number 191, 1967.

Michaud, Michel A.G., "India as a Nuclear Power," paper for the National Security Studies Program, University of California at Los Angeles, California, June 1963.

Morrison, Barry and Donald Page, "India's Option: The Nuclear Route to Achieve Goal as World Power," International Perspectives, July/August 1974. Published by Canadian Department of External Affairs.

Moynihan, Daniel P., "In Opposition," Commentary, March, 1975.

Mukerjee, Dilip, "India's Nuclear Test and Pakistan," India Quarterly, Volume XXX, Number 4, October-December 1974.

Nayar, Baldev Raj, "Treat India Seriously," Foreign Policy, Number 18, Spring 1975.

Oren, Stephen, "India After the Coup," Worldview, April 1976.

Palit, Major General D.K. "L'inde doit construire sa bombe," Réalités, Number 241, 1967.

Palmer, Norman D., "Historic and Modern India," Review of The Soul of India by Amaury de Riencourt. And India: The Most Dangerous Decades by Selig S. Harrison in Orbis, Volume IV, Number I, Fall 1960.

Patel, H.M. "Arrangement with the West," Survival, March/April 1965.

Patterson, Morehead, Addresses at opening of School of Nuclear Science and Engineering, Argonne National Laboratory, Lemont, Illinois, March 13, 1955, and at the Atomic Industrial Forum, Sanfrancisco, California, April 4, 1955. Atoms for Peace Manual, U.S. Congress Joint Committee on Atomic Energy, Washington, D.C.: USGPO, June 21, 1955.

Rao, R. Rama, "India's Nuclear Progress--A Balance Sheet," India Quarterly, Volume XXX, Number 4, October-December, 1974.

Rose, Leo E., "The Foreign Policy of India" in J.N. Rosenau, K.W. Thompson, G. Boyd, World Politics: An Introduction, The Free Press, New York, 1976.

Saha, Meghnad, "Science in Social and International Planning, with Special Reference to India," Nature, February 24, 1945, Volume 155.

Sethna, H.M. and N. Srinivasan, "Fuel Reprocessing Plant at Trombay," from Proceedings of the Third International Conference on Peaceful Uses of Atomic Energy, Geneva, 31 August-9 September, 1964, Volume 10, Nuclear Fuels Fabrication and REprocessing, New York: United Nations, 1965.

Shastri, Lal Bahadur, "India and the Bomb,"Survival, March/April 1965.

Staal, J.F. "Negation and the Law of Contradiction in Indian Thought: A Comparative Study," Bulletin of the School of Oriental and African Studies, Unviersity of London, Volume XXV, Part 1, 1962.

Subrahmanyam, K., "The Indian Nuclear Explosion and its Impact on Security," India Quarterly, Volume XXX, Number 4, October-December, 1974.

______, "India: Keeping the Option Open," in R.M. Lawrence and J. Larus, eds. Nuclear Proliferation Phase II, Kansas: University of Kansas Press, 1974.

______, "The Indian Nuclear Test in a Global Perspective," Lecture delivered August 1, 1974, India International Centre, New Delhi, India.

______, "The Asian Balance of Power in the Seventies," Institute for Defence Studies and Analyses, New Delhi, 1968.

Subramanian, R.R., "India's Nuclear Programs and Superpower Policy in South Asia," Off the record talk to the California Arms Control and Foreign Policy Seminar, Santa Monica, California, January 1975.

Subramanian, R.R., "Notes and Memoranda, India and the Bomb: an Overview," India Quarterly, Volume XXX, Number 4, October-December 1974.

Swamy, Subramanian, "A Weapons Strategy for a Nuclear India," India Quarterly, Volume XXX, Number 4, October-December, 1974.

Trivedi, Statements of October 31 and November 7, 1966, First Committee on Non Proliferation of Nuclear Weapons, United Nations General Assembly, United Nations, New York, 1967.

U.S. Department of State, "India," December 1973, Background Notes.

Wiesner, Jerome, "A Scientist of Both Worlds," Science Reporter, October 1966.

Wilcox, Wayne, "Nuclear Weapon Options and the Strategic Environment in South Asia," California Seminar on Arms Control and Foreign Policy, June 1971.

_____, "Strategic Insurance for India," Survival, Vol. XIV, No. 4 (July/August, 1972), p. 179.

Press

Barron's, "Hard Line or Soft? The U.S. Should Get Tougher with India," Editorial Commentary. February 23, 1976.

Burnham, David, "Environmental Groups Ask Ban on Uranium Shipment to India," New York Times, March 3, 1976.

Chakravarti, P. "PM Affirms Underground Test in Order," Hindustani Times, New Delhi, July 26, 1970.

Drummond, William J., "Indians are Hawkish on A-Power," Philadelphia Inquirer, 31 July 1974.

Grimes, P., "U.S. Freezing Out India in Reaction to Mrs. Gandhi," New York Times, February 29, 1976.

Illustrated Weekly of India, "Explosion in the Desert," Volume XCV, Number 20, July 14, 1974.

UPI (United Press International) "India Considering the Use of Underground Nuclear Explosions, UPI August 28, 1970 (reporting speech of August 26 New York Times).

The Times of India, "PM Inaugurates AEE's Trombay Plutonium Unit," January 23, 1965.

_____, "India's Stand Hailed by Visting Experts," January 24, 1965.

U.S. Department of State, American Embassy, New Delhi, Selected Science and Technological Items from the Indian Press. Monthly reports passim, 1973-1975.