

India, Pa

The Indian subcontinent is the most likely place in the world for a nuclear war

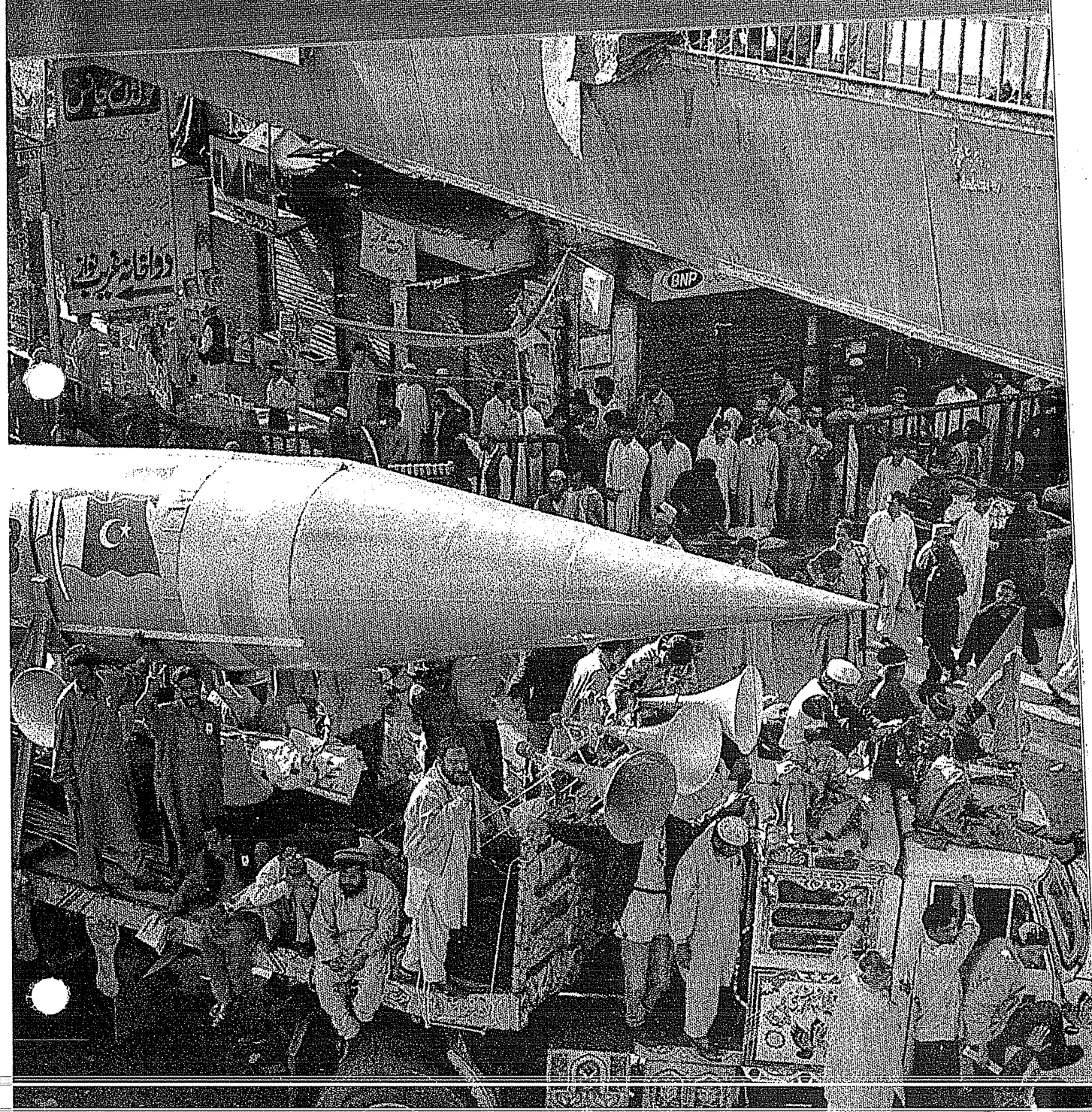
by M. V. Ramana and A. H. Nayyar

THROUGH THE STREETS OF KARACHI, a mock missile is paraded by Pasban, a youth wing of Pakistan's main fundamentalist party, Jamaat-e-Islami. The parade took place in February 1999 on a day of solidarity with Kashmiris in India-administered Kashmir. Such enthusiasm for nuclear weapons is widespread, though not universal, in both India and Pakistan.



AMIR QURESHI/Reuters/Corbis

istan and the Bomb



As the U.S. mobilized its armed forces in the aftermath of the terrorist attacks of September 11, the world's attention focused on Pakistan, so crucial to military operations in Afghanistan. When Pakistani president Pervez Musharraf pledged total support for a U.S.-led multinational force on September 14, many people's first thought was: What about Pakistan's nuclear weapons?

Could they fall into the hands of extremists? In an address to his nation, Musharraf proclaimed that the "safety of nuclear missiles" was one of his priorities. The Bush administration began to consider providing Pakistan with perimeter security and other assistance to guard its nuclear facilities.

The renewed concern about nuclear weapons in South Asia comes a little more than three years after the events of May 1998: the five nuclear tests conducted by India at Pokhran in the northwestern desert state of Rajasthan, followed three weeks later by six nuclear explosions conducted by Pakistan in its southwestern region of Chaghai. These tit-for-tat responses mirrored the nuclear buildup by the U.S. and the former Soviet Union, with a crucial difference: the two cold war superpowers were separated by an ocean and never fought each other openly. Neighboring India and Pakistan have gone to war three times since British India was partitioned in 1947 into Muslim-majority and Hindu-majority states. Even now artillery guns regularly fire over the border (officially, a cease-fire line) in the disputed region of Kashmir.

In May 1999, just one year after the nuclear tests, bitter fighting broke out over the occupation of a mountain ledge near the Kashmiri town of Kargil. The two-month conflict took a toll of between 1,300 (according to the Indian government) and 1,750 (according to Pakistan) lives. For the first time since 1971, India deployed its air force to launch attacks. In response, Pakistani fighter planes were scrambled for fear they might be hit on the ground; air-raid sirens sounded in the capital city of Islamabad. High-level officials in both countries issued at least a dozen nuclear threats. The peace and stability that some historians and political scientists have ascribed to nuclear weapons—because nuclear na-



UNDERGROUND NUCLEAR EXPLOSIONS conducted by India on May 11, 1998, caused the surface immediately above to collapse. Seismic readings (*inset*) suggest that the total explosive yield was between 16 and 30 kilotons, about half of what India claimed.

tions are supposed to be afraid of mutually assured destruction—were nowhere in sight.

Wiser counsel eventually prevailed. The end of the Kargil clash, however, was not the end of the nuclear confrontation in South Asia. The planned deployment of nuclear weapons by the two countries heightens the risks. With political instability a real possibility in Pakistan, particularly given the conflict in Afghanistan, the dangers have never been so near.

Learning to Love the Bomb

BOTH COUNTRIES have been advancing their nuclear programs almost ever since they gained independence from Britain. Understanding this history is crucial in figuring out what to do now, as well as preventing the further proliferation of nuclear weapons. Although the standoff between Pakistan and India has distinct local characteristics, both countries owe much to other nuclear states. The materials used in their bombs were manufactured with Western technology;

SCIENTIFIC AMERICAN ARTICLES ON

NUCLEAR PROLIFERATION

Since the dawn of the nuclear age, SCIENTIFIC AMERICAN has published articles on nuclear weapons policy. A sampling:

The Hydrogen Bomb: II. Hans A. Bethe. April 1950.

The Proliferation of Nuclear Weapons. William Epstein. April 1975.

Stopping the Production of Fissile Materials for Weapons. Frank von Hippel, David H. Albright and Barbara G. Levi. September 1985.

The Future of American Defense. Philip Morrison, Kosta Tsipis and Jerome Wiesner. February 1994.

The Real Threat of Nuclear Smuggling. Phil Williams and Paul N. Woessner. January 1996.

Iran's Nuclear Puzzle. David A. Schwarzbach. June 1997.

both countries' justifications for joining the nuclear club drew heavily on cold war thinking. The continued reliance of the U.S. and Russia on thousands of nuclear weapons on hair-trigger alert only adds to the perceived need for nuclear arsenals in India and Pakistan.

While setting up the Indian Atomic Energy Commission (IAEC) in 1948, Jawaharlal Nehru, India's first prime minister, laid out his desire that the country "develop [atomic energy] for peaceful purposes." But at the same time, he recognized that "if we are compelled as a nation to use it for other purposes, possibly no pious sentiments will stop the nation from using it that way." Such ambivalence remained a central feature of India's nuclear policy as it developed.

To Indian leaders, the program symbolized international political clout and technological modernity. Over the next two decades, India began to construct and operate nuclear reactors, mine uranium, fabricate fuel and extract plutonium. In terms of electricity produced, these activities often proved uneconomical—hardly, one might think, where a developing nation should be putting its resources. Politicians and scientists justified the nuclear program on the grounds that it promoted self-sufficiency, a popular theme in postcolonial India. Rhetoric aside, India solicited and received ample aid from Canada, the U.S. and other countries.



FATHERS OF THE ATOMIC BOMBS: A. Q. Khan (*left*) set up the Kahuta centrifuge plant, which produces the uranium used in Pakistan's bombs. Homi Jehangir Bhabha (*right*), a theoretical physicist educated at the University of Cambridge, laid the groundwork for India's nuclear capability.

After India's defeat in the 1962 border war with China, some right-wing politicians issued the first public calls for developing a nuclear arsenal. These appeals became louder after China's first nuclear test in 1964. Countering this bomb lobby were other prominent figures, who argued that the economic cost would be too high. Many leading scientists advocated the bomb. Homi Bhabha, the theoretical physicist who ran the IAEC, claimed that his organization could build nuclear weapons "within 18 months." Citing a Lawrence Livermore

National Laboratory report, Bhabha predicted that nuclear bombs would be cheap. He also promised economic gain from "peaceful nuclear explosions," which many American nuclear researchers extolled for, say, digging canals.

In November 1964 Indian prime minister Lal Bahadur Shastri compromised, permitting the commission to explore the technology for such an explosion. It turned out that Bhabha had already been doing some exploring. In 1960 he reportedly sent Vasudev Iya, a young chemist, to France to absorb as much information as he possibly could about how polonium—a chemical element used to trigger a nuclear explosion—was prepared. Bhabha died in 1966, and design work on the "peaceful" device did not begin for another two years. But by the late 1960s, between 50 and 75 scientists and engineers were actively developing weapons. Their work culminated in India's first atomic test—the detonation on May 11, 1974, of a plutonium weapon with an explosive yield of five to 12 kilotons. For comparison, the bomb dropped on Hiroshima had a yield of about 13 kilotons.

Nuclear Tipping Point

THE 1974 TEST was greeted with enthusiasm within India and dismay elsewhere. Western countries cut off cooperative efforts on nuclear matters and formed the Nuclear Suppliers Group, which restricts the export of nuclear technologies and materials to nations that refuse to sign the 1968 Nuclear Non-Proliferation Treaty, including both India and Pakistan.

In the years that followed, the bomb lobby pushed for tests of more advanced weapons, such as a boosted-fission design and a hydrogen bomb. It appears that in late 1982 or early 1983, Prime Minister Indira Gandhi tentatively agreed to another test, only to change her mind within 24 hours. One of the causes for the volte-face is said to have been a conversation with the Indian foreign secretary, whom an American official had confronted with satellite evidence of preparations at the test site. The conversation seems to have convinced Gandhi that the U.S. reaction would create economic difficulties for India. Instead, it is reported, she wanted to "develop other things and keep them ready."

The "other things" she had in mind were ballistic missiles. In 1983 the Integrated Guided Missile Development Program was set up under the leadership of Abdul Kalam, a renowned rocket engineer. This followed an earlier, secret attempt to reverse-engineer a Soviet anti-aircraft missile that India had purchased in the 1960s. Although that effort did not succeed, it led to the development of several critical technologies, in particular a rocket engine. Kalam adopted an open management style—as compared with the closed military research program—and involved academic institutions and private firms. Anticipating restrictions on imports, India went on a shopping spree for gyroscopes, accelerometers and motion simulators from suppliers in France, Sweden, the U.S. and Germany.

In 1988 India tested its first short-range surface-to-surface missile. A year later came a medium-range missile; in April 1999, a longer-range missile. The latter can fly 2,000 kilome-

ters, well into the heart of China. Despite this ability, India is unlikely to achieve nuclear parity with China. According to various estimates, China has 400 warheads and an additional 200 to 575 weapons' worth of fissile material. If India's plutonium production reactors have been operating on average at 50 to 80 percent of full power, India has somewhere between 55 and 110 weapons' worth of plutonium [see illustration on opposite page]. The stockpile could be much larger if commercial reactors earmarked for electricity generation have also been producing plutonium for weapons.

Eating Grass

PAKISTAN'S NUCLEAR PROGRAM drew on a general desire to match India in whatever it does. The country set up its Atomic Energy Commission in 1954, began operating its first nuclear research reactor in 1965 and opened its first commercial reactor in 1970. As scientific adviser to the government, physicist Abdus Salam, who later won the Nobel Prize in Physics, played an important role.

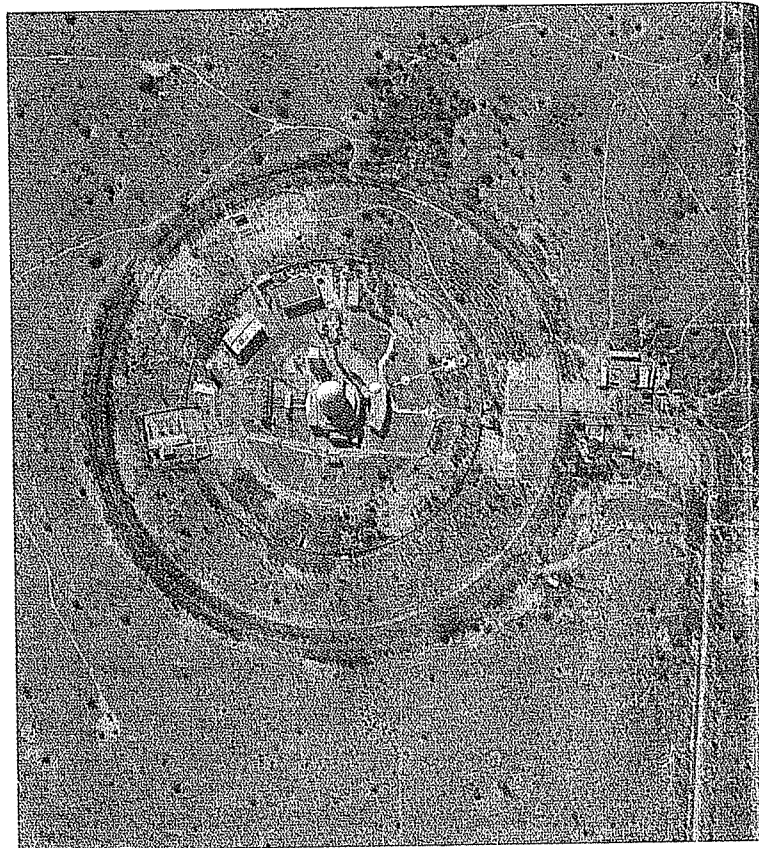
The program was severely handicapped by a shortage of manpower. In 1958 the commission had only 31 scientists and engineers; it was run by Nazir Ahmad, the former head of the Textile Committee. The commission pursued an active program of training personnel by sending more than 600 scientists and engineers to the U.S., Canada and western Europe. With generous help from these countries, some of which also aided India, Pakistan had a few nuclear research laboratories in place by the mid-1960s.

After the 1965 war with India, many Pakistani politicians, journalists and scientists pressed for the development of nuclear weapons. The most prominent was Foreign Minister Zulfikhar Ali Bhutto, who famously declared that if India developed an atomic bomb, Pakistan would follow "even if we have to eat grass or leaves or to remain hungry." After Pakistan's defeat in the December 1971 war, Bhutto became prime minister. In January 1972 he convened a meeting of Pakistani scientists to discuss making bombs.

As the first prong of their two-pronged effort to obtain weapons material, researchers attempted to purchase plutonium reprocessing plants from France and Belgium. After initially agreeing to the sale, France backed down under American pressure. But a few Pakistani scientists did go to Belgium for training in reprocessing technology. Returning to Pakistan, they constructed a small-scale reprocessing laboratory

THE SCIENTIFIC AMERICAN

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KHUSHAB NUCLEAR REACTOR in Pakistan produces a few bombs' worth of plutonium every year. Based on the size of the cooling towers visible in this Ikonos commercial satellite image, nuclear analysts estimate that the reactor generates about 50 megawatts of heat.

in the early 1980s. Using spent fuel from a plutonium production reactor that opened in 1998, this lab is capable of producing two to four bombs' worth of plutonium annually.

As the second prong, researchers explored techniques for enriching uranium—that is, for concentrating the bomb-usable isotope uranium 235. In 1975 A. Q. Khan, a Pakistani metallurgist who had worked at an enrichment plant in the Netherlands, joined the group. With him came classified design information and lists of component suppliers in the West, many of which proved quite willing to violate export-control laws [see box on page 82]. Success came in 1979 with the enrichment of small quantities of uranium. Since then, Pakistan is estimated to have produced 20 to 40 bombs' worth of enriched uranium. Every year it produces another four to six bombs' worth [see illustration on opposite page].

By 1984 designs for aircraft-borne bombs were reportedly complete. Around this time, some American officials started alleging that China had given Pakistan the design for a missile-ready bomb. China and Pakistan have indeed exchanged technology and equipment in several areas, including those related to nuclear weapons and missiles. For example, it is believed that Pakistan has imported short-range missiles from China. But the accusation that China supplied Pakistan with a

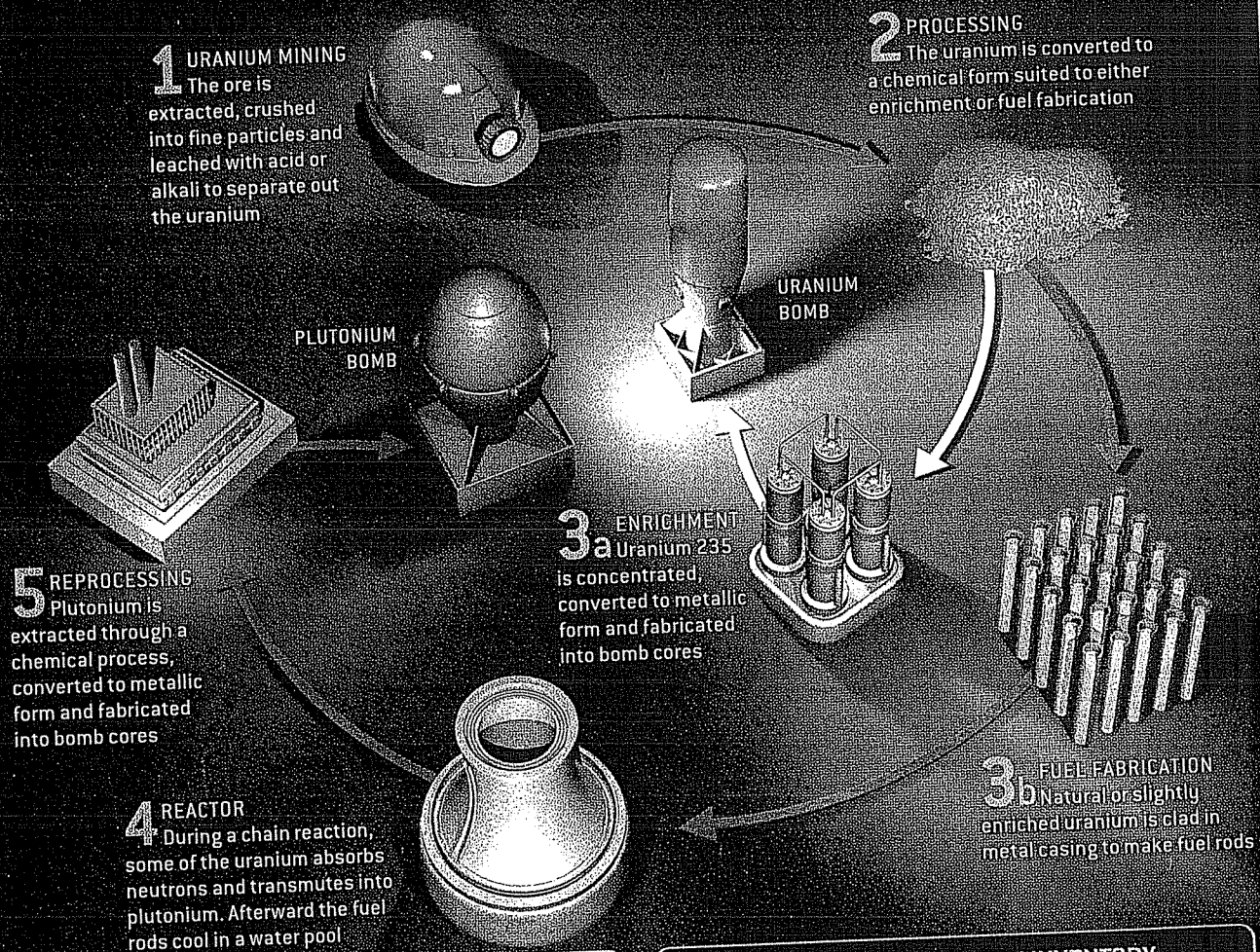
COURTESY OF SPACE IMAGING

MAKING NUCLEAR WEAPONS MATERIAL

THE MOST DIFFICULT part of making nuclear weapons is manufacturing the fuel, either plutonium or highly enriched uranium. The starting point is natural uranium, which is 99.3 percent uranium 238 and 0.7 percent uranium 235. Only the latter can sustain a chain reaction. To build a uranium bomb, one needs to increase the uranium 235 content to 80 percent or more. Most modern enrichment facilities, including the ones in Pakistan and India, use high-speed centrifuges [see "The Gas Centrifuge," by Donald R. Olander; *SCIENTIFIC AMERICAN*, August 1978].

The alternative route involves plutonium. This element is

not found in nature. It is produced by irradiating uranium fuel in nuclear reactors, then extracted through a chemical process called reprocessing [see "The Reprocessing of Nuclear Fuels," by William P. Bebbington; *SCIENTIFIC AMERICAN*, December 1976]. In the most commonly followed reprocessing scheme, the irradiated fuel is chopped up, dissolved in acid and exposed to a solvent called tributyl phosphate mixed with kerosene. The solvent separates out the plutonium and uranium from other fission products. Plutonium is then precipitated out by a reductant, a chemical that changes it to an insoluble form. —M.V.R. and A.H.N.



INDIAN PLUTONIUM INVENTORY

Cumulative production (in reactors):	450–722 kg
Consumption (in tests and reactors):	165 kg
Net stock:	285–557 kg [equivalent to 55–110 bombs]

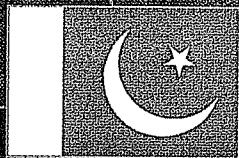
PAKISTANI ENRICHED-URANIUM INVENTORY

Cumulative production (by enrichment):	450–750 kg
Consumption (during tests):	120 kg
Net stock:	330–630 kg (equivalent to 20–40 bombs)

Nuclear Arena

For five decades, India and Pakistan have fought an incessant low-level war in Kashmir and engaged in a nuclear arms race. They now possess large and diverse nuclear weapons infrastructures. Meanwhile hundreds of millions of people in the region remain impoverished.

★ ASHGABAT



Pakistan's Nuclear Establishment⁵

REACTORS

Research/Plutonium Production Reactor, 40-70 MW*
 LOCATION: Khushab
 OPENED: 1998
 FOREIGN PARTNER: China
 MODERATOR: heavy water (?)
 COOLANT: heavy water
 ANNUAL OUTPUT: 6.6-18 kg of plutonium†



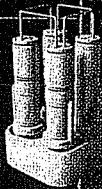
PLUTONIUM REPROCESSING

New Labs
 LOCATION: Rawalpindi
 OPENED: early 1980s
 ANNUAL OUTPUT: 10-20 kg of plutonium



URANIUM ENRICHMENT

Khan Research Laboratories
 LOCATION: Kahuta
 OPENED: 1984
 ANNUAL OUTPUT: 57-93 kg of highly enriched uranium

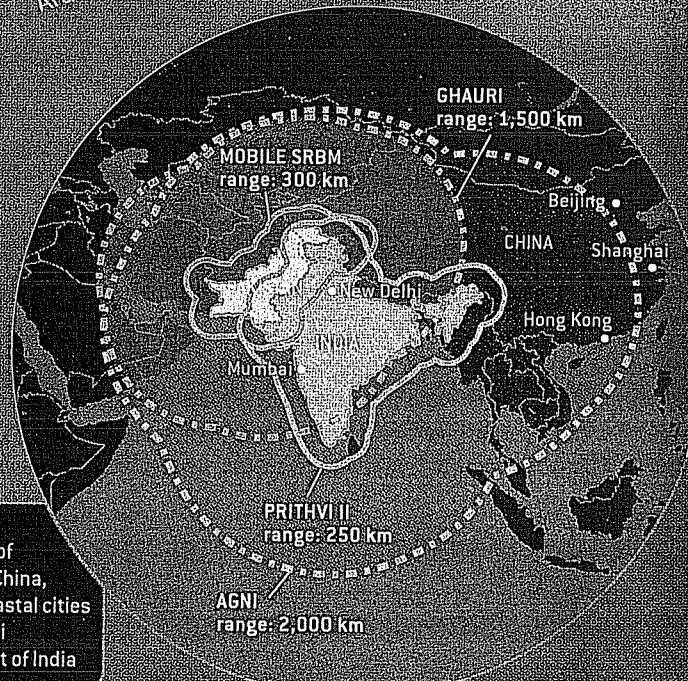


URANIUM MINE

Dera Ghazi Khan
 OPENED: 1974
 ANNUAL PRODUCTION: 23-30 tons

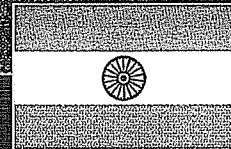
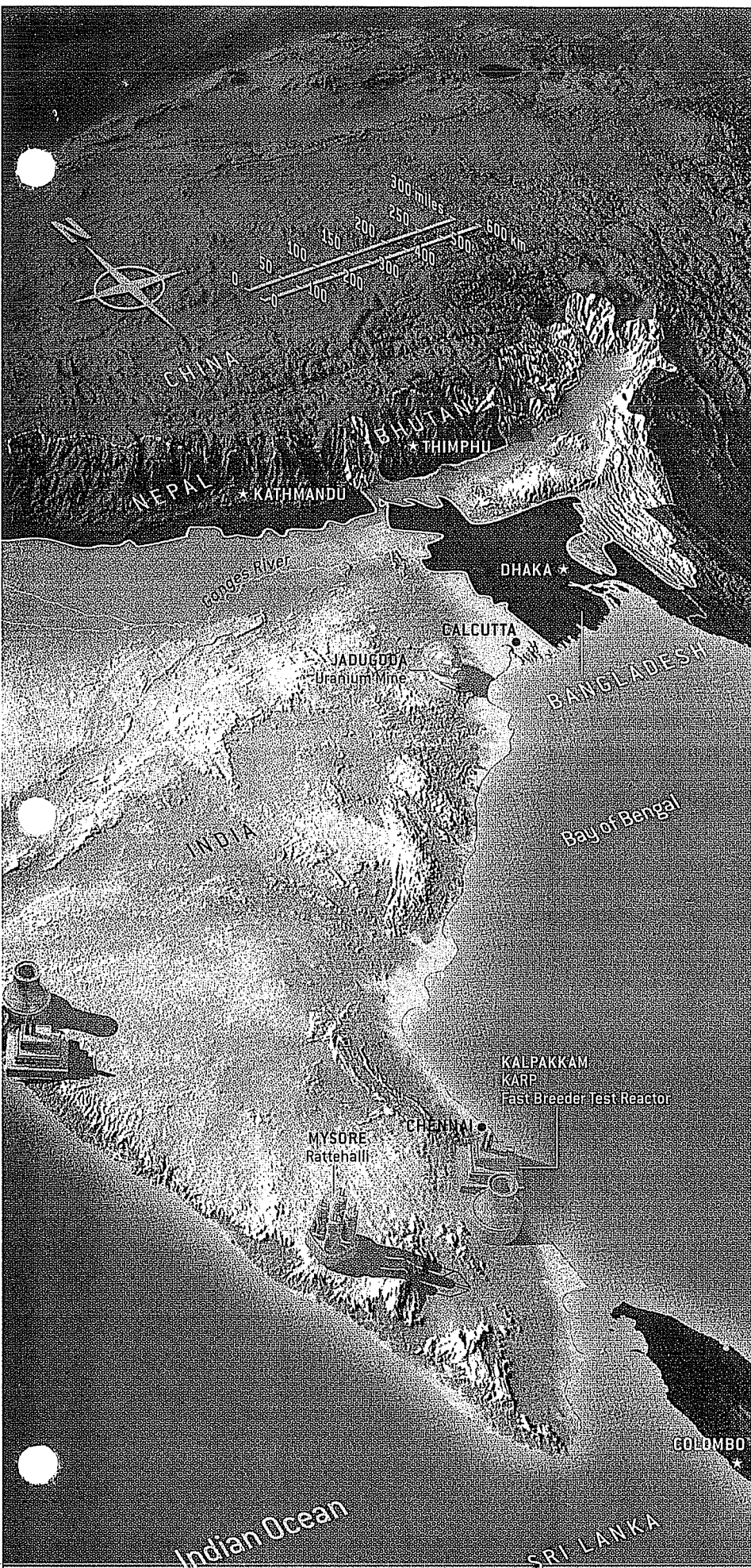


India's longest-range missiles can reach all of Pakistan and most of China, although the major coastal cities are a stretch. Pakistani equivalents cover most of India



★ DOHA

YEMEN



India's Nuclear Establishment⁵

REACTORS

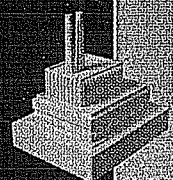


CIRUS, 40 MW*
 LOCATION: Mumbai
 OPENED: 1960
 FOREIGN PARTNER: Canada
 MODERATOR: heavy water
 COOLANT: light water
 ANNUAL OUTPUT: 6.6–10.5 kg of plutonium†

Dhruva, 100 MW*
 LOCATION: Mumbai
 OPENED: 1985
 MODERATOR: heavy water
 COOLANT: heavy water
 ANNUAL OUTPUT: 16–26 kg of plutonium†

Fast Breeder Test Reactor, 40 MW*
 LOCATION: Kalpakkam
 OPENED: 1983
 FOREIGN PARTNER: France
 COOLANT: liquid sodium
 ANNUAL OUTPUT: 4–6.4 kg of plutonium†

PLUTONIUM REPROCESSING



Trombay
 LOCATION: Mumbai
 COMMISSIONED: 1964
 ANNUAL CAPACITY: 30–50 tons of spent metallic fuel

PREFRE
 LOCATION: Tarapur
 COMMISSIONED: 1977
 ANNUAL CAPACITY: 100 tons of spent oxide fuel

KARP
 LOCATION: Kalpakkam
 COMMISSIONED: 1997
 ANNUAL CAPACITY: 100–125 tons of spent oxide fuel

URANIUM ENRICHMENT



Ratthahalli ††
 LOCATION: Mysore
 OPENED: 1990
 ANNUAL PRODUCTION: unknown

URANIUM MINE



Jadugoda
 OPENED: 1968
 ANNUAL PRODUCTION: 200 tons

* thermal power output
 † running at 50%–90% of capacity
 †† used to produce fuel for a nuclear submarine
 ‡ bomb-related facilities; commercial power reactors omitted

weapons design has never been substantiated. And understandably, Pakistan's nuclear scientists have denied it.

In spring 1990 events in Kashmir threatened to erupt into another full-scale war. According to a 1993 *New Yorker* article by American journalist Seymour M. Hersh, U.S. satellites detected a convoy of trucks moving out of Kahuta, Pakistan's uranium-enrichment facility, toward an air base where F-16 fighter jets stood ready. Hersh reported that American diplomats conveyed this information to India, which recalled the troops it had amassed at the border. But the overwhelming opinion among scholars who have analyzed these claims is that Pakistan never contemplated the use of nuclear weapons; experts are also skeptical that U.S. satellites ever detected the claimed movement. Nevertheless, the Pakistani bomb lobby has used the allegations to assert that nuclear weapons protect the country from Indian attack. In India, officials have never acknowledged Hersh's story; it would be an admission that Pakistan's nuclear capability had neutralized India's conventional military advantage.

"Now I Am Become Death"

FURTHER BUILDUP of nuclear capabilities in both countries took place against a background transformed by the end of the cold war. Superpower arsenals shrank, and the Comprehensive Test Ban Treaty, which prohibits explosive tests, was negotiated in 1996. But the five declared nuclear states—the U.S., Russia, Britain, France and China—made it clear that they intend to hold on to their arsenals. This ironic juxtaposition strengthened the bomb lobbies in India and Pakistan.

Domestic developments added to the pressure. India witnessed the rise of Hindu nationalism. For decades, parties subscribing to this ideology, such as the Bharatiya Janata Party (BJP), had espoused the acquisition of greater military capability—and nuclear weapons. It was therefore not surprising that the BJP ordered nuclear tests immediately after coming to power in March 1998.

The Indian tests, in turn, provided Pakistani nuclear advocates with the perfect excuse to test. Here again, religious extremists advocated the bomb. Qazi Hussain Ahmad of the Jamaat-e-Islami, one of the largest Islamist groups in Pakistan, had declared in 1993: "Let us wage jihad for Kashmir. A nuclear-armed Pakistan would deter India from a wider conflict." Meanwhile the military sought nuclear weapons to counter India's vastly larger armed forces.

This lobbying was partially offset by U.S. and Chinese diplomacy after India's tests. In addition, some analysts and activists enumerated the ill effects that would result from the economic sanctions that were sure to follow any test. They suggested that Pakistan not follow India's lead—leaving India to face international wrath alone—but to no avail. Three weeks after India's blasts, Pakistan went ahead with its own tests.

Bombast notwithstanding, the small size of seismic signals from the tests of both countries has cast doubt on the declared explosive yields [see illustration on page 74]. The data released by the Indian weapons establishment to support its



DONNING THE MASK OF DEATH and bearing the Indian flag, protesters gather outside the Pakistani Embassy in New Delhi after Pakistan's nuclear tests in 1998. Some are holding up baby bottles to mock Pakistan as an infant nation. It is not known whether the same protesters had objected to India's own nuclear tests several weeks earlier.

claims are seriously deficient; for example, a graph said to be of yields of radioactive by-products has no units on the axes. Independent scientists have not been able to verify that the countries set off as many devices as they profess.

Whatever the details, the tests have dramatically changed the military situation in South Asia. They have spurred the development of more advanced weapons, missiles, submarines, antiballistic missile systems, and command-and-control systems. In August 1999 the Indian Draft Nuclear Doctrine called for the deployment of a triad of "aircraft, mobile land-missiles and sea-based assets" to deliver nuclear weapons. Such a system would cost about \$8 billion. This past January the Indian government declared that it would deploy its new long-range missile. A month later the Pakistani deputy chief of naval staff announced that Pakistan was thinking about equipping at least one of its submarines with nuclear missiles.

Critical Mass

DEPLOYMENT INCREASES the risk that nuclear weapons will be used in a crisis through accident or miscalculation. With missile flight times of three to five minutes between the two countries, early-warning systems are useless. Leaders may not learn of a launch until they look out their window and see a blinding flash of light. They will therefore keep their fingers close to the button or authorize others, geographically dispersed, to do so.

Broadly speaking, there are two scenarios. The first pos-

INDIAN MISSILES

AGNI ("Fire") I

TYPE: Solid-fueled, first stage;
liquid-fueled, second stage
RANGE: 1,500–2,000 km
WARHEAD: 1,000 kg
DEVELOPMENT STAGE: Suspended

AGNI II

TYPE: Solid-fueled, two-stage
RANGE: 2,000 km
WARHEAD: 1,000 kg
DEVELOPMENT STAGE:
Tested April 1999

PRITHVI ("Earth") I

TYPE: Liquid-fueled, single-stage;
engine based on Russian SA-2
air defense missile
RANGE: 150 km
WARHEAD: 1,000 kg
DEVELOPMENT STAGE: Deployed

PRITHVI II

TYPE: Liquid-fueled, single-stage
RANGE: 250 km
WARHEAD: 500 kg
DEVELOPMENT STAGE:
Tested January 1996

PRITHVI III

TYPE: Liquid-fueled,
single-stage naval missile
RANGE: 350 km (?)
WARHEAD: Unknown
DEVELOPMENT STAGE:
Under development

SAGARIKA (not shown) ("Born on the Ocean")

TYPE: Submarine-launched
cruise/ballistic missile
RANGE: 300 km (?)
WARHEAD: Unknown
DEVELOPMENT STAGE:
Under development

PAKISTANI MISSILES

HATF ("Armor") I

TYPE: Solid-fueled,
single-stage; based on
French sounding rocket
RANGE: 60–80 km
WARHEAD: 500 kg
DEVELOPMENT STAGE:
Tested January 1989

HATF II

TYPE: Solid-fueled,
single-stage
RANGE: 280–300 km
WARHEAD: 500 kg
DEVELOPMENT STAGE:
Tested January 1989

HATF III

TYPE: Solid-fueled,
single-stage
RANGE: Up to 600 km
WARHEAD: 250 kg
DEVELOPMENT STAGE:
Tested July 1997

M-11 (not shown)

TYPE: Solid-fueled, single-stage
RANGE: 290 km
WARHEAD: 500 kg
DEVELOPMENT STAGE: Allegedly
imported from China; in
storage?

GHAURI

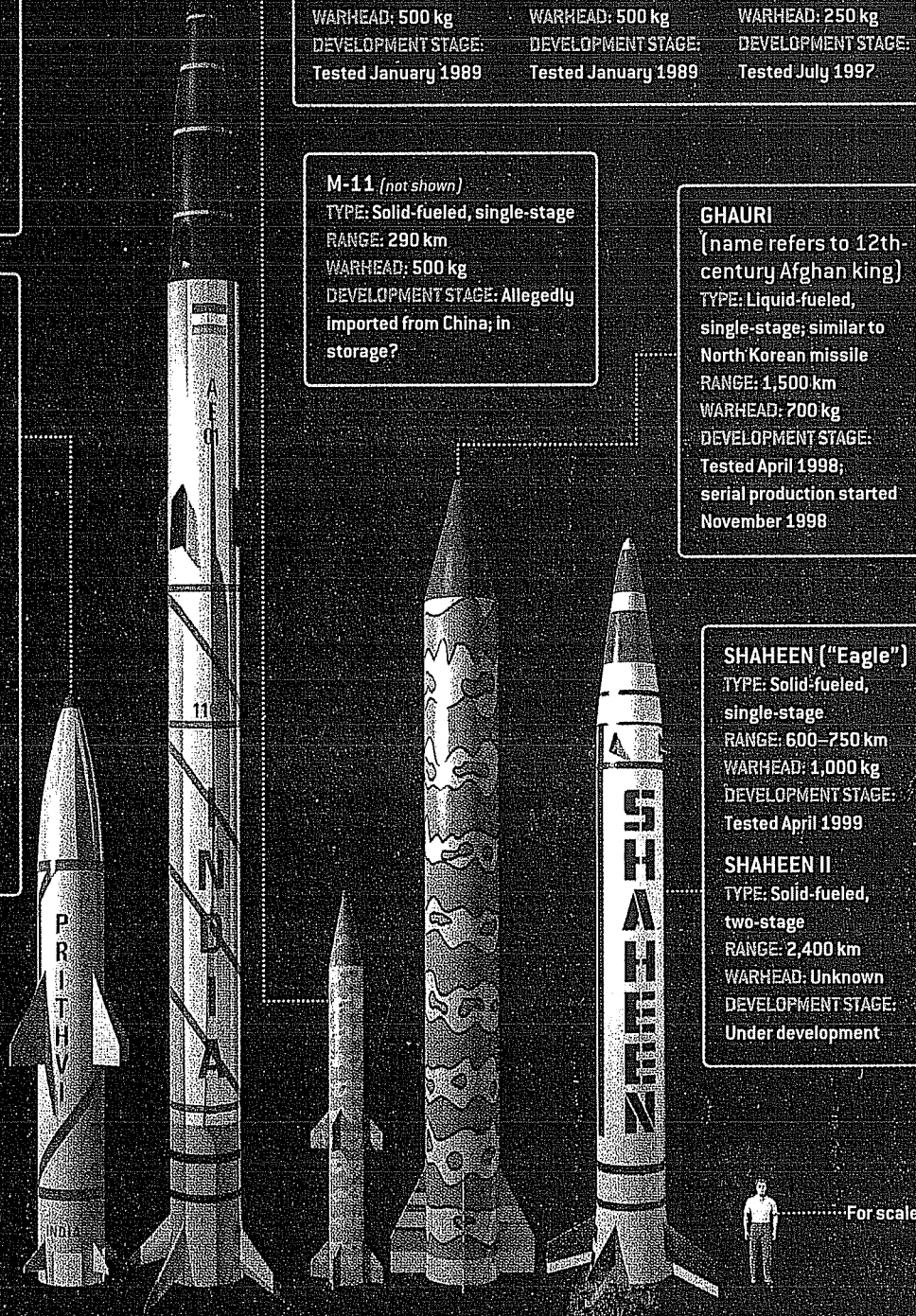
(name refers to 12th-
century Afghan king)
TYPE: Liquid-fueled,
single-stage; similar to
North Korean missile
RANGE: 1,500 km
WARHEAD: 700 kg
DEVELOPMENT STAGE:
Tested April 1998;
serial production started
November 1998

SHAHEEN ("Eagle")

TYPE: Solid-fueled,
single-stage
RANGE: 600–750 km
WARHEAD: 1,000 kg
DEVELOPMENT STAGE:
Tested April 1999

SHAHEEN II

TYPE: Solid-fueled,
two-stage
RANGE: 2,400 km
WARHEAD: Unknown
DEVELOPMENT STAGE:
Under development



tulates that India crosses some threshold during a war—its troops reach the outskirts of Lahore or its ships impose a naval blockade on Karachi—and Pakistan responds with tactical nuclear weapons as a warning shot. The other scenario supposes that under the same circumstances, Pakistan decides that a warning shot would not work and instead attacks an Indian city directly. In 1998 one of us (Ramana)

conducted the first scientific study of how much damage a modest, 15-kiloton bomb dropped on Bombay would cause: over the first few months, between 150,000 and 850,000 people would die.

The Indian military is already preparing for these eventualities. This past May it carried out its biggest exercises in more than a decade, called Operation Complete Victory. Tens

Secrets, What Secrets?

Terrorists might exploit Pakistan's cavalier attitude toward nuclear information

by David Albright

Over the years, successive Pakistani governments have assured the West that they had a secure grip on the country's nuclear weapons, materials and technology. But nuclear analysts have never been entirely comforted by these assertions. Many people in the Pakistani nuclear weapons program and the military could well be sympathetic to radical Islamist or anti-American causes. What is especially worrisome is that the historical development of Pakistan's program has heightened the risk of illegal assistance and other security violations. From its inception, the program has relied on illicit procurement and deliberate deception. It has fostered extensive contacts with the world of shady middlemen and companies whose allegiance to Western export controls depends on the price one is willing to pay. In the organizational culture of such a program, disaffected individuals could find plenty of justifications and opportunities to transfer classified information or sensitive items. Others might be disinclined to report on the suspicious actions of colleagues. Some might even feel ownership over parts of the program and believe it is their right to sell their contributions for personal benefit.

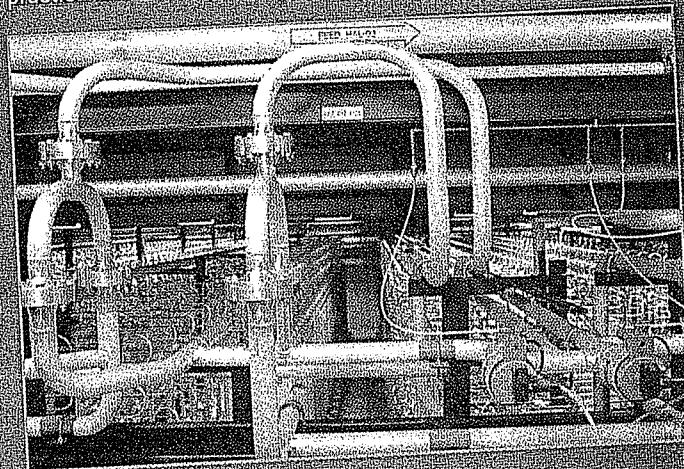
Such problems affect India less, because it started its nuclear weapons program earlier than Pakistan did. India obtained much of its nuclear infrastructure from foreign suppliers before Western governments understood the extent to which developing countries were misusing civilian nuclear assistance to make nuclear explosives. To be sure, Pakistan is not alone in dealing with an organizational culture that scorns security guidelines. The German civilian gas centrifuge program was notorious for its weak security. In the late 1980s German nuclear experts secretly assisted Iraq.

A key component of Pakistan's program, the production of highly enriched uranium for bombs, was born in an act of industrial espionage. In the mid-1970s the father of that effort, A. Q. Khan, worked at a Dutch engineering firm and was given the task of translating classified designs and specifications for gas centrifuges. He gained access to a wide variety of sensitive information. On his return to Pakistan, Khan founded the Engineering Research

Laboratories, now known as the Dr. A. Q. Khan Research Laboratories to transform this knowledge into a bomb factory.

According to a declassified 1983 U.S. State Department memorandum, the enrichment program disguised its activities by providing false statements about the final use of items imported from Western countries. Pakistan once described its gas centrifuge plant as a synthetic butter factory. In a 1999 interview in the Egyptian newspaper *Al-Ahram*, Khan said that his program purchased items through offshore front companies in Japan, Singapore and elsewhere. Those companies took a cut of 15 to 25 percent of the purchase price.

Khan and his colleagues took a Robin Hood approach to classified information. In the late 1980s they published a series of technical articles in Western journals about gas centrifuges. The intention was to demonstrate Pakistan's self-sufficiency in centrifuges and thereby signal that the country was ready to make a bomb. One paper stated its purpose thus: to "provide useful and practical information, as technical information on balancing of



DESIGNS FOR GAS CENTRIFUGES like these, operated by the Urenco-Centec Industrial group in Europe, were acquired covertly by Pakistani bomb makers

of thousands of troops, backed by tanks, aircraft and attack helicopters, undertook drills close to the border with Pakistan. The stated aim was to train the armed forces to operate in an "environment of chemical, biological and nuclear assault" and "to teach the enemy a lesson once and for all." In one significant exercise, the military had to "handle a warlike situation wherein an enemy aircraft is encountered carrying a

nuclear warhead." Abdul Kalam, head of India's missile program, said that India's nuclear weapons "are being tested for military operations ... for training by our armed forces."

Even before September 11, South Asia had all the ingredients for a nuclear war: possession and continued development of bombs and missiles, imminent deployment of nuclear weapons, inadequate precautions to avoid unauthorized use of these weapons, geographical proximity, ongoing conflict in Kashmir, militaristic religious extremist movements, and leaders who seem sanguine about the dangers of nuclear war.

The responses of India and Pakistan to the events of September 11 and the U.S.-led attack on targets in Afghanistan reflect the strategic competition that has shaped much of their history. India was quick to offer air bases and logistical support to the U.S. military so as to isolate Pakistan. Attempting to tie its own problems in Kashmir with the global concern about terrorism, Indian officials even threatened to launch attacks on Pakistani supply lines and alleged training camps for militants fighting in Kashmir. Pakistan, for its part, realizing both the geopolitical advantage it possessed and the dangers of civil instability, deliberated before agreeing to provide support to fight the Taliban. The diplomatic machinations, war in Afghanistan and violence in Kashmir may well have worsened the prospects for peace on the subcontinent. The lifting of American sanctions, which had been imposed in the 1990s, freed up resources to invest in weapons.

The limitations of Western nonproliferation policy are now painfully obvious. It has relied primarily on supply-side export controls to prevent access to nuclear technologies. But Pakistan's program reveals that these are inadequate. Any effective strategy for nonproliferation must also involve demand-side measures—policies to assure countries that the bomb is not a requisite for true security. The most important demand-side measure is progress toward global nuclear disarmament. Some people argue that global disarmament and nonproliferation are unrelated. But as George Perkovich of the W. Alton Jones Foundation in Charlottesville, Va., observed in his masterly study of the Indian nuclear program, that premise is "the grandest illusion of the nuclear age." It may also be the most dangerous. 5A

MORE TO EXPLORE

Fissile Material Production Potential in South Asia. A. H. Nayyar, A. H. Toor and Zia Mian in *Science and Global Security*, Vol. 6, No. 2, pages 189–203; 1997.

The Making of the Indian Atomic Bomb: Science, Secrecy and the Postcolonial State. Itty Abraham. Zed Books, 1998.

India's Nuclear Bomb: The Impact on Global Proliferation. George Perkovich. University of California Press, 1999.

Out of the Nuclear Shadow. Edited by Smitu Kothari and Zia Mian. Zed Books, 2001.

For articles by M. V. Ramana, visit www.geocities.com/CollegePark/5409/nuclear.html

For extensive information on both countries' nuclear weapons, visit

www.isis-online.org/publications/southasia/index.html

www.ceip.org/riies/Publications/tracking10C.asp

www.fas.org/nuke/hew/

centrifuge rotors is hardly available because most of the work is shrouded in the clouds of the so-called secrecy. These articles aided other countries, such as South Africa, in their own nuclear programs.

One Pakistani article is the only publicly available study on bellows built from maraging steel, a superstrong type of steel. For years, Urenco—a British, German and Dutch enrichment consortium—considered the mere mention of these bellows a violation of its secrecy rules.

How much further did the Pakistani nuclear scientists go in spreading the art of bomb making? The U.N. arms inspections in Iraq came across a one-page Iraqi intelligence document, marked TOP SECRET, that contained an offer of nuclear weapons assistance from the Pakistanis. According to the document, an intermediary approached Iraqi intelligence in October 1990—two months after the Iraqi invasion of Kuwait and three months before the U.S.-led counterattack—with the following proposition: Khan would give Iraq bomb designs, help to procure materials through a company in Dubai and provide other services. In return, Iraq would pay handsomely.

Arms inspectors were unable to find the middleman, and Pakistan and Khan have denied any involvement. Nevertheless, the Iraqis took this offer as genuine—and apparently rejected it. Khidhir Hamza, a former weapons scientist who left Iraq in 1994 and worked with me in the late 1990s, says he knew of this offer at the time and believes Iraq would not have pursued it, for fear that Khan would gain too much knowledge about, and control over, Iraq's nuclear programs. Khan already had a track record of misleading the Iraqis, having used a contract for a petrochemical facility as a cover to obtain maraging steel.

In March of this year, the government of Pakistan removed Khan as head of the nuclear laboratory and offered him a position as a special science and technology adviser. The move is widely viewed as an attempt to rein him in. This past summer, however, reports emerged that the laboratory has kept up its ties with North Korea's ballistic missile program, reviving fears of nuclear cooperation. Pakistani officials have denied any connection.

No evidence links elements in the Pakistani government with any terrorist group, but the Pakistani government has had extensive contact with the Taliban. It is conceivable that terrorists could exploit these connections to gain access to sensitive nuclear items. The culture within the nuclear program increases this risk.

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