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Putting Pokhran in Perspective

Frontline magazine in its latest issue talked to India's atom chief Dr R Chidambaram about the efficiency and effect of recent nuclear tests. The interview is published here to shed light on the technical aspects of the tests.

According to Dr. R. Chidambaram, Chairman, Atomic Energy Commission (AEC), and Secretary, Department of Atomic Energy (DAE), "a dozen new ideas and systems" were tried out in the five nuclear tests carried out at Pokhran in Rajasthan on May 11 and 13. "And all of them worked perfectly well." With the data yielded by the tests, he said, "we have now built an adequate scientific database for designing the types of devices that we need for a credible nuclear deterrent. So from a scientific point of view we advised that we could now announce a moratorium on testing because no more tests were considered necessary by us."

Dr. Chidambaram asserted that "India carried out the tests based on today's knowledge of physics, engineering, materials science and electronics, (and) there is a kind of leapfrogging here, and each one of the tests should be considered equivalent to several tests carried out by other nuclear weapon states over decades."

Dr. Chidambaram, whose term as AEC Chairman was extended by two years from December 1, 1998, was in Chennai on December 9. In a 70-minute interview he gave T.S. Subramanian, he answered a range of questions. Excerpts:

TSS: There is a controversy about the total yield of the five nuclear tests conducted at Pokhran in May 1998. Roger Clarke, a British seismologist, has agreed with the assessment of the Department of Atomic Energy that the total yield of the three tests conducted on May 11 was around 60 kilotonnes. But another group of seismologists disputes this. For example, University of Arizona geophysicist Terry C. Wallace wrote in the journal Seismological Research Papers that the yield was 10 to 15 kilotonnes on May 11, and 100 to 150 tonnes on May 13. Bhabha Atomic Research Centre (BARC) scientists S.K. Sikka, Falguni Roy and G.J. Nair wrote in the September 10 issue of Current Science (published from Bangalore) that the interference between the seismic waves from the two main explosions on May 11 would have led to a lowered estimate of the seismic signal strength at stations situated in the eastern and western directions. They have argued that only the data from the stations situated in the northern and southern directions should be taken into account. Can you put the record straight?

RC: It is always difficult to correlate the seismic magnitudes with yields unless it is a well-calibrated testing site like Nevada in the United States or eastern Kazakhstan in the erstwhile Soviet Union. It is also susceptible to deliberate manipulation, as happened between the Soviet Union and the United States. In our case, for the tests on May 11, there is the further complication caused by separated but simultaneous explosions, when the seismic signals interfere, as you mentioned, and their unfamiliarity with the Pokhran geology. The latter is important because the strength of the seismic signal is determined by the way the explosive energy couples into the geological medium, and there are strong regional differences. In fact, each seismic station has to be calibrated, and this is obvious from the range of seismic magnitudes reported by various global seismic stations. A small difference in body wave magnitude of a little over 0.2 corresponds to a halving of the yield estimate. And for any underground nuclear explosion, seismic body wave magnitudes are known to range over 1.0 or even more, which indicates the pitfalls in yield estimates from seismic signals, unless they are done carefully and correctly. This has been done by BARC scientists, using four different methods, and the details have been published in the November 1998 issue of BARC Newsletter.

The first method is to look at the body wave magnitude, or mb. Here is where the asymmetry from the seismic records of the various stations in the world comes into the picture. Because the two (main explosives on May 11) were located in shafts oriented east-west with a separation of one km, the seismic signals produced from them superpose with a phase lag depending upon the direction. However, if one looks at the signal which has been recorded in the northern direction, for which the phase lag is zero, one can clearly see the difference. In fact, if we plot mb versus the orientation, say zero degree for the north, 90 degrees for the east and -90 degrees for the west, you get a bell-shaped curve; in other words, if you allow for this orientational effect, the body wave magnitude for the two tests is 5.4, which corresponds to about 60 kilotonnes, which we had announced immediately after the experiments. This is also consistent with our yield calculations, that is, based on our computer calculations. The design values and the announced experimental yields soon after the tests were 15 kilotonnes for the fission device and 45 kilotonnes for the thermonuclear device (popularly known as the hydrogen bomb); and there was also the small sub-kilotonne device, with a yield of 0.2 kilotonne.

The second method is more straightforward. As I mentioned earlier, the one problem is that you must know the geological medium in which the device has been emplaced before you venture into yield estimation because that decides how much energy couples into the (geological) medium from the device. Then you must calculate the absorption along the path from the point of detonation to the seismic station. Since there is no global or universal model for the earth, these absorptions along the various paths could be different. Unless the site has been calibrated well, you can make serious mistakes in estimating the yields from seismic magnitudes. On the other hand, if the site and the seismic station have been properly calibrated together, these effects can be eliminated.

The third method used by the BARC scientists was to look at surface waves, which are less susceptible to geological variations. By looking at the surface wave magnitude - Ms, as it is called - from four stations of the United States Geological Survey and three of our own stations, the average comes to 3.62. That is, Ms is equal to 3.62. Then, using the standard formula which relates Ms to the yield, the yield works out to 58 kilotonnes.

All the above methods of measurement are based on internationally available seismic data, which - with all its defects - is the only way anyone can look at other countries' underground nuclear explosions. In fact, seismic monitoring is one of the methods for the international monitoring system of the Comprehensive Test Ban Treaty (CTBT).

The fourth method that the BARC scientists used was to look at the close-in acceleration measurements and compare them with the U.S. data. The U.S. data are available for the dry hard rock of the Nevada test site and the sedimentary formations in Colorado, where the U.S. has carried out two peaceful nuclear explosion experiments - Rulison and Rio-Blanco. When they scaled the yields, our data fit with the Colorado data and not with the Nevada test site data. This is what we expected because the Pokhran medium is closer to the sedimentary formations in Colorado, where these two experiments were carried out, than with the rock in the Nevada test site. So here again, the acceleration measurements are consistent with the yield of about 60 kilotonnes. If we accept the Nevada site parameters, the Pokhran-II yield will go much higher, to 100 kilotonnes.

TSS: So we have plenty of data now. From all these data, it is very clear that the yields of the devices we tested on May 11 are exactly what we announced immediately after the tests.

RC: As you correctly said, a number of international seismologists have agreed with our yields within the limits of experimental error. But this one group of seismologists in the U.S. seems to have ignored some of the factors that I mentioned before, and in particular the fact that the U.S. geostations are crowded round an angle westerly to the northern direction. As I explained in the beginning, they are likely to get lower body wave magnitude signal, and this seems to be the main reason for the lower value given by them. On the other hand, it also raises serious questions regarding software and analytical inadequacies in the global seismic network for monitoring simultaneous but separated underground explosions around the world.

It is not surprising that they did not detect the sub-kilotonne explosions of May 13 because the threshold for the CTBT in terms of sensitivity of detection is around one kilotonne when the Global Seismic Network is fully operational, which is not likely to be before 2002. The only station from which they could monitor our Pokhran tests was at Nilore, in Pakistan, which, I think, is at a distance of about 740 km from Pokhran.

TSS: About a couple of hours back you said in your commemorative address at the Indian Overseas Bank foundation day that seismic data could be "manipulated". You also said that the International Data Centre (IDC) had misdiagnosed the tests as "an earthquake on the India-Pakistan border." Can you elaborate on that?

RC: (Laughs.) Even though the Prime Minister had announced on May 11 itself that we had carried out the tests, the Internet message from the International Data Centre for several days after this was that there had been an earthquake on the India-Pakistan border at the time of the tests! That gives you an idea of how well seismic monitoring works!

It is also that during and after the signing of the Threshold Test Ban Treaty, which set the limit for testing at 150 kilotonnes, the Americans routinely overestimated the yields of the Soviet tests in order to accuse them of violating the Treaty. In particular, I remember one instance when the Americans accused the Soviet Union of testing a device at 300 to 500 kilotonnes, well above the 150-kilotonne limit. But later, when the Americans went and examined the geology of the site where the Soviet Union had carried out the test, they agreed that the yield was indeed below 150 kilotonnes. This emphasised the importance of knowing the geology of the site well or the need to calibrate it properly before one can make any statements about the yield of the device tested, from seismic measurements.

Another interesting example was that after the CTBT was signed, the Americans accused Russia of carrying out a sub-kilotonne explosion in the Arctic region, while seismologists all over the world knew that it was an under-sea earthquake, 100 km away from the Arctic test site!

So my feeling is that unless one has competent seismologists and good analytical software, one can make honest mistakes. But there is always the possibility of manipulating data, as in these two examples I cited.

TSS: What are the basic characteristics of a neutron bomb, a hydrogen bomb, a fission device, and a plutonium bomb? When I met you last time you said there was no difference between a neutron bomb and a hydrogen bomb.

RC: Basically, there are two types of devices. One is the pure fission device and that can use either plutonium or highly enriched uranium. Here, you start with the configuration which is sub-critical and then you increase the density of the nuclear material by implosion or you assemble pieces of material together or both so that you reach a super-critical configuration. And if you start a chain-reaction at the proper time, from that time onwards until the system becomes sub-critical again through disassembly or a little later, there will be energy released. This is a typical fission device. You can put into this device fusion material which essentially acts as a source of additional neutrons once the fission device operates and thereby increases the yield of the device. You can call it a fusion-boosted fission device. Well, you can decrease the energy of the fission device so that it comes to the sub-kilotonne range. This has to be done very carefully because when you are trying for marginal supercriticality, there is always a chance that if you make a mistake, it may not reach criticality and it may become a fizzle.

The very satisfying thing from India's point of view about the three sub-kilotonne tests was that our computer calculations were so exact that we could predict very accurately the yields of the three devices that we tested.

In the thermonuclear device, or hydrogen bomb as it is called, there are at least two stages. The first stage is a fission device and one uses the radiation energy from this stage to detonate the second stage, which contains the fusion material. In advanced hydrogen bomb designs, the primary stage is a fusion-boosted fission device in order to get increased radiation energy density.

In the case of the thermonuclear device that we tested, the primary stage was a fusion-boosted fission device. For a nuclear scientific community of India's capability, there was really no need to test separately a fusion-boosted fission device. That is why we decided to use it as the primary in the thermonuclear device. In fact, it is very interesting that The Times, London, said that India had carried out "sophisticated tests of modern nuclear weapons". As I have said before, the five tests that we carried out are based on advanced designs of 1998 vintage.

In the five tests that we carried out, we tried out a dozen new ideas and systems. And all of them worked perfectly. We have now built an adequate scientific database from the tests for designing the types of devices that we need for a credible nuclear deterrent. So from a scientific point of view we advised that we could now announce a moratorium on testing because no more tests were considered necessary by us.

Negotiations on the CTBT are, of course, a political question, and I have no comments on that.

TSS: What is the yield range of fission and thermonuclear devices?

RC: I know that fission devices have been designed up to a yield of at least 100 kiltonnes. This was the work of Theodore Taylor. Thermonuclear devices can be made in the range of megatonnes. (One megatonne is equal to 1,000 kiltonnes.) But they have been made as small as a couple of kiltonnes also. I remember one U.S. peaceful nuclear explosion test called Cabriolet, where they tested a small thermonuclear device for excavation purposes whose yield was as low as 2.3 kilotonnes, of which the fission trigger was probably only a hundred tonnes. Even though they called it a PNE device, this is also the prescription for a neutron bomb! So thermonuclear devices can go from a couple of kilotonnes or even less to megatonnes. The consequent conclusion is that from the yield of a device, you cannot really make out what kind of device has been tested.

TSS: Will the five nuclear explosions themselves constitute a minimum nuclear deterrent as is being claimed?

RC: The deterrent weapons have to be built from the three types of devices which we successfully tested. You should not just count the number of tests. First, the number of tests has to be related to the number of types of devices that you want to develop. The Americans, for example, carried out more than a thousand tests. But they developed 70 to 80 types of devices. The Chinese have carried out 45 tests.

The second point to remember is that suppose you were testing three decades ago, you would carry out your design on the basis of the then existing knowledge of physics, materials science, engineering and electronics. Suppose your knowledge improves, suppose you had a better computer available to you, suppose your electronics improved as it indeed did over the decades, you would redesign and test again. But basically, it could be the same device. This will get repeated again and again over the next few decades.

So if in 1998 India had carried out the tests based on today's knowledge of physics, engineering, material science and electronics, there is a kind of leapfrogging here, and each one of the tests should be considered equivalent to several tests carried out by other nuclear weapon states.

TSS: Some countries brought in the entry-into-force clause, which says India should accede to the CTBT by September 24, 1999. Otherwise, the CTBT would collapse. Don't you think this is an assault on India's sovereignty ?

RC: It is a very unusual clause because so far as I am aware, there is no other treaty in which there is an enforced requirement of signature of a list of states before the entry-into-force.

TSS: Yes, 44 states which have access to fissile material. Article XIV of the CTBT states so.

RC: Yes.

TSS: Why were the five tests carried out in such a rapid sequence? Was it out of fear that if they were not carried out now, international pressure would mount on India later to accede to the CTBT?

RC: It was a very carefully planned series of tests, and the design and planning was carried out over a number of years. As time passed, the designs were continuously improved. That is why we were prepared to carry out tests at short notice. Of course, if we had tested a few years back, the designs would not have been as advanced as they were when we tested them in May 1998. Yes, indeed it was a rapid sequence because I do not know of any other instance where five tests were carried out within a span of 48 hours when the devices were of three different basic designs.

TSS: But there have been instances. The Soviet Union once exploded eight nuclear devices simultaneously.

RC: I don't think anybody has exploded within 48 hours such a variety of devices as we did.

TSS: If India had not conducted the five tests, what would have been its stand?

RC: I will put it this way. The one test that we carried out in May 1974 was surely inadequate. But the five tests we have done now, after such careful planning, have given us enormous and very valuable database.

TSS: Does this database give us the capability to do sub-critical experiments in the future, which are not barred by the CTBT?

RC: There is a multiplicity factor, called K, which is the ratio of the neutron population in a given generation to that in a previous generation. K equal to one is the 'Lakshman rekha' for the CTBT. You are not supposed to cross this line if the CTBT comes into force and you are a signatory to this Treaty. This means that if you plan experiments which take K close to 1, your calculations must be accurate enough to ensure that crossing beyond K equal to 1 does not happen. The fact that we carried out three very precise sub-kilotonne tests, which take the system marginally above K equal to 1, means that our capability to do such critical tests, if found necessary in the future, is now established.

I must also mention that from whatever reported data I have seen about such sub-critical tests by the United States, they have been far from criticality. I must add that at the moment, we are not planning any sub-critical tests.

TSS: What about India's capability to go in for computer simulation?

RC: This again has to be related to the fact that there was a perfect match between the calculated and the measured yields in all our tests. In the early days, when they carried out a computer design calculation for a device, the actual yield would be far away from the calculated yield, often being off by a factor of two or more. And then they will adjust some parameter in the calculation to get a match between the calculated and the measured yields. If they did several tests, they would have several parameters to play with and thus have a computer simulation package. The errors were even more in the case of a thermonuclear device.

But today, since we have got experts in practically every branch of physics which goes into the design of the various types of nuclear devices, we did not have to do any empirical parameter fitting but could go ahead with first principle calculation. That is why I am confident that we have the so-called computer simulation capability in this field.

TSS: In what ways were the nuclear tests of May 1998 an improvement over the nuclear explosion of May 1974? The 1974 test was earlier called a PNE experiment but now it has been admitted that it was indeed a nuclear bomb.

RC: The 1974 test was important since it gave us the confidence to carry out the 1998 tests. The design of the fission device has been vastly improved, and the others are, of course, new designs. From physics design-wise, there is no difference between a nuclear weapon and a PNE explosive. Obviously, the same physics has to go into both. What is different between the two are the packaging and the detonation methodologies. The experiment that we carried out in 1974 was a PNE phenomenology experiment.

TSS: Were the nuclear tests of May 1998 inescapable? Could India not have got the data through computer simulation?

RC: This is like saying that only theoretical physics is enough and that we don't need experiments.

TSS: What was the yield of Pakistan's two tests? Pakistan claims it conducted six nuclear tests - five on May 28 and one on May 30.

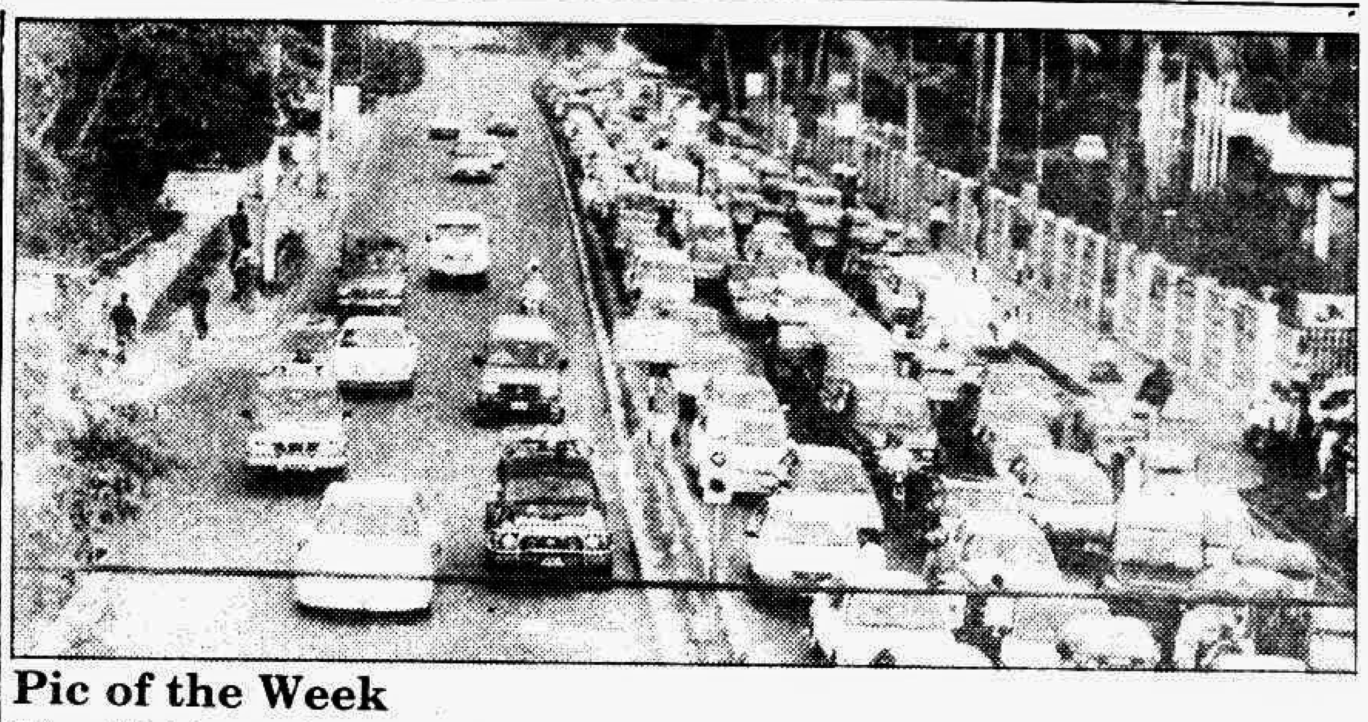
RC: The signal at Gauribidanur (station in Karnataka) which we recorded for the May 28 test (of Pakistan) was between five and ten kilotonnes. The Americans estimated it at six kilotonnes. The yield from the test carried out on May 30 (by Pakistan) was about half as much. However, as these estimates are based on seismic body wave magnitude again, these can be off by a factor of two.

Pakistan claims that it carried out five tests in the same horizontal shaft (on May 28), which is unusual because, after all, tests are intended for gathering data. And separating data from such closely spaced devices would be very difficult. So it is very unusual - their claim that they conducted five tests in a (single) shaft. It is much easier to dig a separate shaft for each device like India did and like everyone else usually does, except in very special situations. For example, in the Rio-Blanco tests, which the Americans did for gas stimulation, they emplaced three 30-kilotonne devices in the same vertical shaft. But these were not tests as such but actually used for a PNE application in order to fracture a large rock mass.

TSS: What is the status of the Koodankulam Power Project? Has work started on preparing the detailed project report (DPR)?

RC: Actually, the supplement to the Inter-Governmental Agreement was signed by me and Dr.Yevgeny Adamov, Minister for Atomic Energy of the Russian Federation, when he came here in June 1998. Later the Chairman and Managing Director of the Nuclear Power Corporation of India Limited (Y.S.R. Prasad) went to Moscow to sign the agreement on the preparation for the detailed project report. This will take about two years to prepare.

There is a multiplicity factor, called K, which is the ratio of the neutron population in a given generation to that in a previous generation. K equal to one is the 'Lakshman rekha' for the CTBT. You are not supposed to cross this line if the CTBT comes into force and you are a signatory to this Treaty. This means that if you plan experiments which take K close to 1, your calculations must be accurate enough to ensure that crossing beyond K equal to 1 does not happen.



Pic of the Week

Prime Minister on the wrong lane

The Week in Review

Sir Found Guilty

A Dhaka University inquiry on Jan 10 found Prof Shahiduzzaman of International Relations guilty of sexual misconduct.

The fact finding committee that submitted its report to the syndicate on Jan 10 probed the allegation by a female MA student of Public Administration, who complained of sexual abuse by the Professor. The committee recommended legal action against the accused teacher, as per university rules, that is "sacking a teacher for moral turpitude".

The DU Syndicate had earlier suspended Prof Shahiduzzaman on the basis of an interim report of the inquiry committee in the wake of a campaign launched by a section of students under the banner "Students Protesting Sexual Harassment."

Universities to Reform

Eight amendment bills were finalised on Jan 11 aiming at restructuring university administrations with provisions for appointing one or more provosts to deal with the onerous task of managing present day campus.

Workers' United ...

Two jute workers were beaten to death and 25 were hurt on January 10 in Khulna, when activists of rival factions of Jatiya Sramik League clashed at the Peoples Jute Mills at Khalishpur over payment of wages and Eid bonus.

Police arrested seven persons but none of the groups filed any case with the police.

SEC Gets Real

The capital market regulators on Jan 11, adapted new public issue rules prescribing "full and fair" disclosure in the prospectus, for ensuring informed decisions by investors. The new rules require the issuing company to make adequate and full disclosure while offering shares and securities. The companies sponsored by bank loan defaulters will be allowed to offer public issue of securities which was earlier prohibited. Any order by a regulatory authority 'suspending or otherwise limiting the involvement of any officer or director of nominee in any type of business, securities or banking activities must be made public under the new rules, the prospectus should also incorporate whether during the last ten years "any bankruptcy petition filed by or against any company of which any officer or director or nominee of the issue filing the prospectus was a director, officer or general partner at the time of bankruptcy within two years period to that time."

Acting on Andamans

India announced on January 10 that she will set up a new naval command on her eastern coast to counter threats to its security. It is to be based in the Andaman and Nicobar Islands and hoped to come up in next few weeks.

This would protect the insecure and vulnerable region and counter any threat from China, which has reportedly, surveillance posts in 40 km off the northern tip of Andamans. The command would also help facilitate search and rescue and anti piracy operations.

DSE Gets Tough

The Dhaka Stock Exchange on Jan 9 fined a brokerage firm Tk 20 lakh and handed it a one month suspension from trading for market manipulation.

The DSE council penalised SPM Ltd for manipulating the market using Quasem Silk shares on Nov. 3, 1997.

The council took this unanimous decision after two hours of deliberation.

This decision was taken to rebuild the lost image of the bourse and its council in the eyes of investors and others concerned.

Assault on Child

A school girl was sexually assaulted on Jan 9, allegedly by a neighbour in Narsingdi, while returning from school.

According to police sources, Baset Ali violated his neighbour's 8-year-old girl when she was returning from Basail Government Primary School after collecting free books.

Hearing cries of help, people rushed in and caught Baset red-handed.

Defense Crash

An Avro aircraft carrying four scientists of India's top defence research centre crashed on Jan 11, in a southern Indian state. The scientists and all four crew members were killed.

The aircraft was owned by the Defence Research and Development Organisation and had taken off from a Naval air base in Arakaman, 1,725 km south of New Delhi.

Terror Arrested

Detective police on Jan 8 arrested one Nurul Absar, a terrorist of a secret organisation named 'Freedom in Bangladesh' in a pre-dawn raid at Bahatterpool, Chittagong.

Murder by the Sea

Unidentified assailants on Jan 11 stormed into the house of a businessman (former officer of Chittagong City Corporation) and gunned down his son and nephew.

The victims, Deear Mohammad (Milon), 24, and Imam Hossain (Ripon), 18, were asleep, when they forcibly entered their residence, sprayed bullets on the two and fled.

A case was filed and Chittagong DB men was ordered to investigate the case.

Bhai in the Soup

Movie moghul and business tycoon Aziz Muhammad Bhai was arrested from Gulshan area on Jan 6, for his alleged involvement in activities detrimental to social and economic interests of the country. Aziz is also a suspect in the film star Sohel Chowdhury murder case.

Bhai, held on various charges was grilled with a volley of questions on his satellite channel 'ATV'. In the name of sending recorded tapes to ATV, he leaked out state secrets Special Branch officials alleged.

Aziz Mohammad Bhai denied all the allegations saying he had no relations with any political party or entity.

Magic Bus

The first trans-border link between India and Pakistan began its final 'dry run' on Jan 8, prior to launching the bus service late January. This is hoped to increase people-to-people contracts and ease the uncertainty and mutual suspicion which cloud bilateral relations.

Clinton in the Dock

The Senate convened on Jan. 7 to begin the first presidential impeachment trial with intense, last minute bargaining over ground rules.

Senators took oath to 'do impartial justice' and chief justice William Rehnquist assumed his role as presiding officer for Clinton's trial on charges of perjury and obstruction of justice.

Sangu's Sixth

Petrobangla allowed British Oil Company Cairn to drill a 6th well in the offshore Sangu gas field to optimise gas production there.

The country is currently consuming 850 mmcfd gas. Of this Sangu supplies 100 mmcfd and Petrobangla pays for it in foreign currency.

Banks Bankrupt

Two state owned industries are limping due to fund constraints. Bangladesh Shilpa Bank (BSB) and Bangladesh Shilpa Rin Rangstha (BSRS) are non-functional and bankrupt due to huge funds of overdue loans and lack of credit line, causing many projects to become non-existent or non-viable.

Experts feel that adequate financial support and making bank loans free from all kinds of political influence would help proper industrialisation.

WASA Water OK

Sample tests of Dhaka WASA water by four water expert teams revealed that the arsenic content is much below the permissible limits, i.e. 50 ppb. The samples were taken from Puratan Jhigatala, Dhanmondi-8, Mohammadpur, Mohakhali, Gulshan-4, and Civil Aviation Authority of Bangladesh in Uttara.

I-Spy, UN-Spy

UN Secretary General Kofi Annan obtained convincing evidence on Jan 6 that UN weapons inspectors helped the US collect intelligence to be used in Washington's efforts to undermine Iraqi President Saddam Hussein. He accumulated enough information which showed that the UN Special Commission (UNSCOM) assisted US in listening to some of Baghdad's most sensitive communications.

Money for Something

The Executive Committee of National Economic Council on Jan 6 approved seven projects at an estimated cost of Tk 893.81 crore, including project aid component of Tk 670.02 crore.

Out of this Tk 522.18 cr was projected toward infrastructural development to speed up economic activities in the Chittagong Hill Tracks region. The meeting was presided over by PM Sheikh Hasina.

Opps Get Shirty

BNP, JP, Jamaat-e-Islami, and five other opposition parties gave the government an ultimatum to accept a four point charter of demands including a revamped Election Commission ahead of the forthcoming local government polls. They also 'warned to "boycott" the polls if these demands were not met.