Distr.
LIMITED

PAMM/AIHTTR/GC/II-S/13/80
21 April 1980

Original: ENGLISH

ECONOMIC COMMISSION FOR AFRICA

African Institute for Higher Technical Training and Research

Governing Council, 2nd Session

Nairobi, 14-19 May 1980

REPORT ON INDIAN STUDY VISIT
(24 February - 28 March)

by

Prof. M.O. Chijioke

The main objective of the month-long visit was to survey and assess Indian industrial and training strategies for technical manpower production in as many as possible of the technological areas in which the African Institute for Higher Technical Training and Research will operate, in particular to study what problems of technology adaptation and implantation they have encountered as a developing sub-continent, indeed as one of the leading developing nations, and how useful to the African scene such experiences can be. Accordingly a careful mix from the best known of India's higher technical educational and industrial manufacturing firms representative of all sizes, together with some associated high calibre research institutions of varying philosophies, were identified some one to two months before the tour and the necessary governmental permissions sought through the UNDP. The final response was very reassuring in that out of 26 establishments, permission to visit was granted for all but two, one a research body, the other a hardware production factory. The list of organizations visited is attached.

The first impressive feature of India's industry is its consistency with an overall national pattern generally ascribed to Pandit Nehru's planning genius immediately after their 1947 independence from British rule, but also by some, at least in its conceptual stages, to Vishishtry before Nehru. It is astonishing to learn that as British rule in India drew to its close with the whole country still splintered into Raj-ruled States, there was only one technical training institution, and that not even upto a higher diploma level, established by the imperial power (in Roorkee in North India, one of the institutions I visited), and then training not Indians as much as Britons who were later absorbed in the Indian or other civil service! (Up till some 20 years ago, I was informed the principals, largely British, still insisted on dinner suits being worn into the staff dining hall.) Today, less than 50 years later, India's industrialization

efforts are very redolent of Japan's earlier this century, especially in the strong policy and material involvement of the central government. It now has 98 universities, 38 offering engineering programmes and including the best known of them, the five Indian Institutes of Technology (IIT); 102 colleges operating to post-graduate levels as colleges of designated universities; four strategically located regional colleges; many high level research institutes covering most fields of scientific endeavour (some of which however are not open to foreign visitors) including numerous firms in capital and naval and military equipment production; Centres of Excellence and Centres of Studies for Resources Engineering to look after specific technological concentrations, such as the Regional Sophisticated Instruments Centre being now developed in the IIT, Bombay, all these aside from the innumerable small and medium scale industries, in textiles for example - the age-old sinew of India's economy - which the government studiedly nurtures alongside such megaliths as Tata and front-line research organizations as the Bombay Textiles Research Association (BTRA). One effect of this gigantic assault on the technology gap is that India has today the third numerically largest force of high-level scientific manpower after the USA and Russia!

The funding of these organizations is the first index of their placements in a nation-wide plan in which front-line technological research, basic and industry-oriented are the responsibilities respectively of federal-owned (i.e. completely federally funded) IITs along but definitely subsidiarily with 50% state-funded universities on the one hand, and on the other federal-owned research centres dedicated to specific trades such as texiltes, machines and tools, chemicals, aircraft, rolling stock, rocketry and space vehicles, nuclear energy, etc. a success story that astonishes already in its ramifications, and certainly achieves visibly more than that of many earlier-starting Western countries with smaller potentials in terms of a technically productive population and fewer natural resources. (In fact such countries already constitute a fast-growing market for India's manufactures!)

One reason for the success is the studious effort to minimize gratuitous duplication, a certain sign of co-ordinated planning in a sub-continent of which the size, population, literacy rate, religious and ethnic diversities and even today's extents of States' autonomy would otherwise precipitate a completely debilitating replication of industrialization efforts, atomistic, individually inadequately capitalised and nationally inefficient. Instead there exists today such capitalistic and capital-intensive combines as Hindustan Machine Tools, Hindustan Aeronautics, Bharat Electricals, Tata Industries (hydra-headed), the Electronics Corporation of India, Larsen and Toubro's, ... all nation-wide in the distribution of their factories (some of which are whole villages employing as much as 100,000 workers) and international in the distribution of their products. Even more striking their growths have been so monitored and incentive-directed by government that their productions are fully complementary rather than competitive, pricing controls being automatically ensured by the moderate subsistence levels, abundance of local labour and consequently international competitiveness of India's pricing policies. There is no technical manpower shortage, not even of physicists (usually the scarcest of them all) and I encountered everywhere signs of a current liberal policy on the export of technical manpower in the production of which large-scale industries now contribute significantly and compulsorily. No doubt more products competition will

grow after this initial strengthening of the industrial base, but I have a feeling that it will be guided still to meet an increasingly favourable export demand rather than an already fully exploited local buyers' market.

1. [illegible] Pre-eminence of Regional Macro-planning of Technological Development

The lessons here are firstly, the efficacy of region-wide or at least multi-national planning, not only in infrastructural ventures such as transportation and education, but also in the capital-intensive industries such as ship-building and air-craft industries, where product demand albeit vital, and resource investment, at the critical levels may be more than may be mobilised by one state alone. Another essential function of such industries, and one even closer to the heart of the AIHTTR project, is illustrated by a second-rung objective of industry-based research in India. A well-seeded group of federally owned capital goods firms are deliberately sited close to federally owned technical educational institutions so as to enjoin (not merely encourage) a symbiotic interaction between classroom and factory. This has been one of the more potent channels to the 'total technology' idea wrongly claimed these days to be new-fangled and to originate from Europe. Thus for example, the Bharat Heavy Electricals (BHEL) Ltd. factory in Bhopal producing [illegible] the largest electromechanical equipment, like hydrogenerators and steam-turbines, to heavy-duty transformers and high-voltage insulator banks, maintains as close an operational interface as possible with the Machine Design teaching programme of the Maulana Azad College of Technology (MACT) close-by; and M. Tech. (Master of Technology) students of the programme, and to a lesser extent its B. Techs, alternate between BHEL and MACT in a very realistic interflow of factory-training and applications research.

One of the Regional Colleges, MACT is a "college" only in that its degree programmes are vetted by Madras, its assigned university in its South Eastern Region. Again this structural component of India's overall strategy should be noted. Madras is not only one of the oldest university centres of [illegible] of the five best known centres of higher technical education (the IIT's), approximately each dominating a geographical region. So do the four Regional Engineering Colleges of Bhopal (on 650 acres as MACT, associated with BHEL), Hyderabad (associated with the Electronic Corporation of India) Trichinopoly with another BHEL branch, and Allahabad with compressors India Ltd. And as the Principal of MACT, Dr. B.L. Mehrothra explained, these Regional Colleges were deliberately "established as pace-setters" at a 75/25 Federal/State budgetary participation, the post-graduate courses being however entirely federal-supported.

The pace-setting refers of course to the quality of products, not only due from the impliedly better federal funding than in the universities, but also from the innovativeness of training methods already illustrated in reference to BHEL. Unfortunately by the sheer size and scale of products

of organizations like BHEL the all-important factory-floor training of students has to be done more by "observation" than "participation", as the MACT engineering professors reluctantly agreed; and it is still a moot question whether a via media of reduced scale is possible where even at reduced turnovers (distinguished from 'profits') the total technological training of "producing while learning" can be achieved in extra-mural industry and as intensively supervised (a sine qua non to its success) as in its intra-mural version. This last also exists, to my entranced surprise, in India with an almost identical development to the rubric for the IIPC (the Inter-disciplinary Industrial Production Centre) of the AIHTTR as prepared before my Indian tour. This alternative approach to innovative technical training is described next.

2. The Scope of Intra-Mural Industry in 'Total Technology' Training

It has operated in Coimbatore (near Madras) since 1921 (!) in the PSG College of Technology, a "fifth brother" (i.e. public trust) legacy by the four founding-father sons of the State Raj, who stipulated that its proceeds must all be ploughed back for the public good. In present day terms these proceeds of "the Industry" as the College simply calls its Production Centre, maintain the budgets of the PSG College and of some ten other public educational, medical, etc. institutions developed by the Trust, to the extent of 10-25% of the entire budget of the College alone. This is over and above the funds ploughed back into the Centre which has expanded tremendously in the interim. In comparison MACT earns some $25,000 annually on industrial consultancies, "which is shared 50/50 between College and Consultants ... and is enough to meet some 40% of the College's recurrent budget". In turn MACT contrasts in this respect with the IITs and universities that have no compulsary commitment to, and may earn no fees at all from industrial collaboration. For readiest assessment the operation of the PSG Industrial Production Centre will be described in terms of its practically achieved policy parallels with the proposals for the AIHTTR's.

Firstly, both within the techniques of its production and over the spectrum of its product types the Centre is multi-disciplinary so as the more capably to feed the various disciplines of the College, all technical as for the AIHTTR (complete with the basic sciences of physics, chemistry and mathematics), and multi-level (sub-degree Diploma to Ph.D. outputs). Each department is limited to about 500 students overall - the AIHTTR proposal is 500-1000 per Centre according to demand and as long as it is the only institution of its type in the region. The PSG Centre started with and has kept to the production line of electric motors with which the AIHTTR also plans a take-off, but has predictably extended this to compressors and, later, to machine tools. The Machines Shop housing over 100 of the most sophisticated tool-shaping and gear-cutting machines (horizontal boring, profile-grinding, hobbing, notching pair, plano-grinding automatic, single- and double-column planning automatic, this last Indian-made, with a six-metre travel version @$200,000), is currently the highest foreign exchange earner in the centre through its lathes of 0.75m. and 1m. beds @$4,000 only all-in; and the College's "machine tools and metrology facilities are the best in all India."

It is fair to mention here one contrast with the AIHTTR: namely the PSG "Industry" started before the College, and much more simply with motor repairs and sui generis studies of motor parts assemblies and materials, although these days when motor patents have largely lapsed there should, as the College agreed, be no need for such "re-invention of the wheel" tactics for take-off.

A further important parallel for technical skills development is that the PSG Centre is some 80% labour-intensive, in comparison with say BHEL or Hindustan Machine Tools which are about as much capital-intensive. It accepts systematically for factory-floor training 10% of its work-force as students (Diploma to M.Tech.) every day for the whole day, thus facilitating students' full experience of shop-floor requirements. The College however has for its spread of academic, research and training activities, the surprisingly high student/staff ratio of 25. In addition it opens its workshops (and as in AIHTTR plans, departmental workshops operate along with the Production Centre) on week-ends to students from neighbouring secondary schools with no more than one normal day's pay as honorarium to participating staff; thus the dedication of the founding spirit of the institution is maintained.

The Production Centre itself with none of its six factory bays (for Machine Tools, Pumps Assembly, Heat Treatment, Electrical, Welding and Press Shop and finally the 100'X70' Foundry) less than 60'X70', is in organization all but completely separate from the College because "their requirements are different": in the AIHTTR it is proposed that the Academic Board's role in the IIPC be only consultative on issues of common interest. (But I thought it a mistake carried over from other arenas of India's technical education that no specific industrial experience is required of College Staff who are however some 30% Ph.D. holders.) The Centre is run purely on commercial lines (a basic requirement of the IIPC and a stormground of argument even by ECA multi-agency review groups, which I certainly was glad to see practicalised). It runs profitably without doubt, as is evidenced by its budgetary support of several public institutions; but as its General Manager agreed it would equally doubtlessly show more profit did it not have to spend some time on students (invariably accompanied however by one or two teaching staff).

Also the College's "departments" are more akin to the AIHTTR's "centres" than to traditional departments. Not administered in faculties, they each have direct access to the college Principal and to the body responsible for attachments to the Production Centre, and are responsible for their extra-mural consultancies. Finally the Boards of Studies of these departments (of which I coincidentally observed their annual syllabus review gathering, this time for the epochal shortening of the duration of the engineering degree programme to match a revised national integrated educational plan) are drawn from the College, its University, industry and specific high-level technical institutions like the Indian Institutes of Science and of Technology.

My impression is that the implementation of a total technological education in this institution has achieved a resounding success, nationally in the export drive and in manpower quality, and intramurally in the consultancy level equippages of all teaching departments and their industrial quality project outputs - from a complete television transmitter and receiver in the Electrical Engineering Department to the fact that the Physics laboratory in electro-optics, working in collaboration with a European country, is one of the only two Indian establishments I heard about in micro-electronics advanced as far as semi-conductor crystal growing from imported polycrystalline silicon and germanium. This view is apparently also the Indian government's which recently conferred on the College an exceptional honour as one of 8 out of 150 engineering "Colleges of Excellence" granted an autonomous status i.e. independence of the university's vetting in its teaching programme innovations and processing. I cannot do better than conclude the review of this College by quoting from my notes that "I could only rue after the first half-hour of talks ... that I had not heard of this institution's activities full five years earlier (!)... Such earlier knowledge would have saved me literally years of 're-inventing the wheel' of an inter-disciplinary Industrial Production Centre, first in the Nigerian Institute of Management and Technology, and even more energy in convincing doubting Thomases ... that what (they thought) was 'theorising' on the possibility of, is in fact a possibility."

3. Government Policy Involvement

Yet apart from the view that such a total technology programme requires uncommon dedication by staff my question remained largely unanswered why this scheme of technical education has not spread like fire throughout India at least. I believe the capital investment and recurrent costs have a lot to do with the answer. Textiles Technology, one of the five departments, has alone a workshop of some $2.5 m. industrial-scale machinery, and the Production Centre has over the years built up equipment costing over ten times that amount. The Indian government may also consider, especially if it ignores the invisible returns, that visible profits lost during training exceed those lost by the alternative MACT-BHEL approach which itself is being tried as pace-setting in only four centres. Such a view would be truer of yet a third alternative which, as another useful lesson of the Indian experience, typifies the firmness of resolve with which the government prosecutes its developmental policy in technology. Every major firm is required by law to take in technical trainees, whether they eventually employ these or not, numbering at least 6% of its work force. Observed as much as it appeared to be by every qualifying firm I visited, this tactics could eventually produce more skilled craftsmen than all more formal vocational schools put together.

In summary therefore my visit to the PSG College, Coumbatore, found that: an industrial production centre of precisely the type proposed for the AIHTTR is eminently feasible and with a judicious choice of product lines can attain break-even within 4 years - the AIHTTR will have rather more favourable conditions for reaching break-even in that, for instance, the IIPC will have available such multi-disciplinary feeder programmes as electromechanical and later chemical engineering, and there are current UNDP programmes that could ensure our avoidance of both the Scylla of extortionist patent rights and the Charybdis of reinventing the wheel; and identified ready collaboration for starting work as soon as we wish on the IIPC, including PSG and MACT professors who have been with their own project from almost its start, have views which identify fully with the spirit and philosophy of the AIHTTR, and have kept abreast of development in technical education planning. Important ideas floated by one such staff include the integration of the electromechanical workshop into the IIPC to reduce capital costs at least at first, trainees' workshops being one full day a week rather than distinct 3-hours-a-day periods, and some "Modern-Look" programme case-studies of London's Imperial College very akin to the IIPC.

4. Comprehensive Disciplinary Coverage and Geographical Distribution

The fourth lesson of the Indian experience is the care with which areas of support in high-level research or teaching are chosen and those of industrial production encouraged, to cover fully all fields of modern scientific endeavour, and are sited for even development not only in the metropolitan centres of Delhi, Bombay, Calcutta and Madras, but in Satellite Suburbia like Poona the pre-colonial capital, beautiful Bangalore and Bhopal, Kharagpur, Roorkee, Hyderabad and Ahmedabab. The following sample distribution is very informative in the linkages of this industrial chain.

(i) Bombay - for Textiles Technology (a) National Textiles Research Association (BTRA) - funded 50/50 by the central government and the textiles industry; main role: non-profit making textiles technology transfer to both the centralized and decentralized (cottage industry) sectors. Already collaborating in overseas LDC programmes e.g. in Kenya. (b) The Victoria Jubilee Technical Institute affiliated to Bombay University offers in its "Textiles Manufacturers Dept" diploma and degrees programmes ("among the best in India") in textiles technology and design. (c) Tata Textiles - private major industry, though started in 1914 by the British and a member of the organization BTRA. The Chief Executive warned that promises of external support for any big technological endeavour in the LDC's go largely unredeemed during implementation, and that multinational projects such as the Colombo Staff College get bedevilled by the politics of multi-lingualism and multi-ideologies; but he saw some conditions under which the reluctance to transfer technology may be overcome in cases. (d) Indian Institute of Technology - its 22-year old 200 ha campus by Powai Lake houses the national Sophisticated Instruments Centre which is statutarily available to the public of the Western

Region for 60% of the time, and to all IITs. IITs are fully autonomous and meet regularly in an IIT planning Council e.g. to determine the siting of Centres of Excellence. They encourage staff, consultancies (which fund often 40% of research) up to 50% of the individual's salary. Federal post-graduate and research funding is liberal and projects are not fund-limited. Each IIT is limited to 2000-2500 students (40-45% post-graduate). Well over 90% of all staff and all students (student/staff ratio of 7!) are housed on the self-contained campus. Students catering management is through an elected volunteer Hostel Food Committe assisted by Institute-paid kitchen staff and warden. (e) University of Bombay - concentration departments of Biochemical Technology and Pharmaceuties complained uniformly of debilitating fund shortages. Their food processing B.Sc Tech. Programme (3 years after B.Sc in Science) and B.Pharm (3 years after Inter B.Sc) do have 4 months of industrial attachments all told. The high staff/student ratio of 15 here should be compared with the IITs' 7; ditto their federal matching (50%) all-in grants received through a University Grants Commission, and their meagre consultancy involvement.

(ii) Poona, near Bombay-(a). The Environmental Design post-graduate studies at Poona University caters for all Maharashtkra, some 80m people, and was just then producing research designs for replanning and decongesting Bombay. Relies heavily on visiting lecturers from industry. (b) Rocketry and Missiles research at the Military College (visit not possible). (c) Equipment Industries - several hight to medium-scale private industries such as Vulcan-Laval which produces pumps, compressors and sheet-metal goods.

(iii) Hyderabad. (a) The headquarters of the National Remove Sensing Agency with its main earth terminal built and commissioned within 10 months entirely by Indians in 1975. Specializations include photogrammetry and aerial photos processing and interpretation, with an impressively 350-strong multi-disciplinary staff from agriculturists to geomorphologists and navigators. A typical "Registered Society", it is run by Dr. K.R. Rao, the sole Director, an eminent scientist responsible only to an "Accounting Board", as a cross between a public service and a private profit-making industry. (b) Modern Electronics and Nuclear Products at the prestigions 1000-acre Atomic Energy Agency Site. In particular the 3000-staff Electronics Corporation of India is typical of a few wholly indigenously developed ('non-collaborative') technological undertakings. Started 30 years ago as a basic research facility, it progressed into applied research and then industrial production in most electronic fields from medical and nuclear instrumentation to computers - its mark III TDC316 electronic digital computer is already sweeping the minicomputer market of India. (It is very comforting to mention my enconutering at this point evidence of the interest or advanced activity of several individual countries like Turkey, Nigeria, Tanzania, Kenya... in collaborating with India to develop national institutions of a similar concept to the AIHTTR in single (e.g.. Electronics or Textiles) or in several disciplines). Here I got perhaps the fullest statement of employers' attitude to R. & D training: a general preference to inculcate "on-line" the requisite

R & D capabilities specifically referred to factory products, requiring educational institutions before them to instill self-confidence in equipment deployment and practical self-reliance to the maximum possible degree.

(iv) Madras: (a) Technical Teacher Training in one of the only four institutions in India in this field that started surprisingly late (at most a decade ago) and even now is very restricted in intake and in its target of "polytechnic staff only". Neither the B Tech. Ed nor Diploma course (each of 1 year duration for graduates and diplomates respectively) adds much to existing courses in the African region, but their supporting educational technology workshops - the focus of the visit-complete with micro-teaching (closed-circuit television), film-processing facilities and multi-media teaching aids, would at least equal the best available here. (b) Coimbatore with the best Machine Tools, Metrology and Total Technology teaching facilities in India in the above-discussed PSG College Production Centre. (c) Beautiful Bangalore (near Madras) with the impressive trio, government-owned as in the well-known Japanese precedent, and largely disposed to collaboration within the LDC's of: the Bharat Electronics combine, the "electronics pioneers in India" now producing every thing from high-powered (100 kw) transmitters to modern computer-aid designed micro-electronic components; the Central Machine Tools research Institute, "employing 150 design engineers"; typical of the research establishments without a prime profits motive and started in collaboration with Czechoslovakia, mainly services now government high-level R & D needs including adaptations, in electromechanical and electronic instrumentation (a current collaborative UNDP project with CMT is the development of electronic numerical R & D machines control); and the 22,000 work-force Hindustan Machine Tools Company that now has reversed the flow of heavy duty lathes from Russia and West Germany among others. Also the Indian Institute of Science that has grown from a research institute in the physical science to a well-known educational institution in post-graduate engineering, specializing in solid state physics and cryogenics; and finally Hindustan Aeronautics Ltd. which had not yet received the clearance for my visit. (v) Calcutta University, a national Centre of Excellence in Applied Physical Sciences including Electronics, and which supports some 260 M.Sc's and 100 Ph.Ds in physical chemistry, propagation and solid-state thin-film work - a cache of available staff talent. Kharagbut (near Calcutta) IIT, a Centre of Excellence in Micro-electronics, housing the National Cryogenics Centre Laboratories, and strong specializations also in Mining and Mineralogy, Naval Architecture, Agricultural Engineering, Rural Technology and Aeronautics, is currently reorganizing from a department to a 'centre' concept (as in an exchange of notes, I found, are also Oxbridge in their engineering laboratories, and the University of Virginia in a complete systems-based reordering of its programmes). Strong self-reliance in very well-produced high-level test equipment particularly in Aeronautics, Naval Construction and Mining, was evident, partly enforced by their explained "lack of rich collaboration uncles" as in other IITs. Has the largest (180,000 text) library and specialization-spread so far encountered, and very keen staff of 400 with 2,750 students.

(vi) Delhi (a) The Indian Institute of Technology here took some pains to defend (poorly the IITs' general inattention to industrial training and its own government-enforced attention to technology adaptation. Its concentrations are in Production Engineering and Electronics - it houses the national Tribology Centre and the Centre for Applied Research in Electronics (CARE), both impressively equipped for modern research. All groups of professors I chatted with are keen on consultancy activities.

(b) The Central Road Research Laboratories (CRRL), another non-profit motivated government body recently transferred from the national Committee for Scientific and Industrial Research (CSIR) to the Ministry of Technology, and consequently dropping its formerly 20% of basic research activities: its main role is to feed the Transportation Planning Division with research input on roads, traffic and concrete, conduct seminars, and retrieve similar information for which it is now a UN Regional Centre.

(c) The Televista Company, with a Television assembly line staff of 130, was visited as typical of the smaller industries. Its staff training is all on the job, namely the wiring and assembly of complete hybrid television receivera - they did not show their other claimed lines of tape recorders, calculators and microcomputers. Their techniques and product sophistication illustrate most directly India's strategy of "second-line technologies to start with". (vii) Roorkee (180 km. north of Delhi) University already cited, with the most deliberate 'foreign students' provisions I met thus far. Concentrations in Minerals and Metallurgy, Water Resources, Highway Engineering ("the famous tri-axial testers were invented here") with strong collaboration with the CRRL, and Surveying and Photogrammetry. Its "low-cost rural transportation research has in 5 years achieved the reduction by 50% of unconnected villages". Each of its specializations as listed is worth further study by appropriate heads of divisions, perhaps utilizing the ECA/UNDP - India accords on manpower exchanges. (viii) The touristically attract - Bhopal (half way from Delhi to Bombay) with the already discussed pace-setting MACT-BHEL Heavy Machines Design pairing, in which BHEL staff lecture as well as induct MACT trainees on-line. (Substantial involvements of UNDP and UNESCO in the equippage of MACT laboratories). A disappointment of this visit was the remarked absence of any a priori preferential remuneratio by BHEL for instance, of the M-Tech over the non-specialist B-Tech employees whom the former exceed numerically in MACT.

(BHEL productions range from 250 megawatt capital-intensive turbine generators to labour-intensive 'electronic modules' for train traction. This traction division has four bays each 900' by 60'-80' wide; and there is an Ultra High-Voltage Lab capable of 1.5 MV dc and 4MV/0.4 MJ impulses. The Technical Teacher Training Institute makes with Madras's the two best of India's four. The two programmes also compare equally including their emphases on polytechnic curricula and multi-media teaching-aide development plus, in Bhopal, educational management.)

(ix) Ahmedabad's Indian Institute of Management added at the eleventh hour and thanks to UNDP (Delhi's) accommodation, would have been a great miss otherwise. After the PSG College, MACT-BHEL, and Kharagpur's IIT, it was the fourth high point of the tour from the point of view of interest and inspiration. The best known of India's, again four IIMs, its scholastically inspiring design, to begin with, exacts tribute; and although its modular course designs (for a high-quality 2-year MBA and a doctoral level Fellows Programme) cover only generally and do not cater specifically for engineering managemement, their Post-Graduate Diploma and six-month long executives' seminars could. Indeed more than half of the trainees often are technical personnel. Dr. Udai Perek, the Professor of Organizational Design, comparing their limitation of size to 180 students ("in pursuit of personal staff-student contacts") with the AIHTTR's likely size, felt that their theory of a critical size of institutions (contradicted by USA examples) would be best met in the AIHTTR by a 'centre-based' structure, and solicitously continued that the AIHTTR should emphasize in teaching a prime awareness of national economic realities, motivation to small entrepreneurships, the management education of engineers and an institutional building role.

Larsen & Toubro's are manufacturers of electromechanical systems such as complete paper-producing plants and electrical switch-gear; their general manager from Ahmedabad made the one criticism of the IIM's MBA that "its graduate elects to forget his engineering in expectation of bossing others from his air-conditioned office."

5. Non-lessons

The following shortcomings of the Indian system are also worth noting as pitfalls. First the speed of progress from the general 'second-rank' to 'front-rank' technological research in practice appears slow despite avowals to the contrary. Most of the up-to-sate components and equipment from basic polycrystalline silicon (not to mention gallium arsenide) to large-scale or real small-scale integration as district from thin-film MIC,+ are still imported; but it may be a question of time before this picture changes significantly. Then in some areas of encouraging success the approach looks unnecessarily experimental or hesitant still - in the favouritism to the IIT's alone for example, or the non-multiplication of the PSG College structure. Some of the environments of the factories seen would clearly do with some inspecting and updating - to avoid for instance dusty or steamy atmospheres and guard dangerous machinery. Then India has been a very late starter, perhaps diverted by the IITs, in developing technological universities per se, although it has now just started with a couple. of this pivotal establishment for modern industrially manpower.

In fact both the IITs and the National Council for Scientific and Industrial Research are being criticised for not quite meeting the objectives set for them; I personally noticed a certain amount of IIT professional disdlaim, at professional levels for undergraduate teaching,

---

+ micro-integrated circuits

not to speak of the industrial training of technical manpower. Finally the absence of training programmes dedicated to technology management and planning, has already been noted.

However most of these are comparatively minor failings that need only time for correction or are already on the way to correction. Indian industry as a whole and given the appropriate elevation of the general level of basic education, bids fair to make her the Japan of the early 21st century, and ought to receive the full attention of Africa's technocrats and technologists.