Gaining Technical Know-How in an Unequal World: Penicillin Manufacture in Nehru's India

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I. Introduction

For the first of the Jawaharlal Nehru Memorial lectures held at New Delhi in 1967, P.M.S. Blackett chose the theme of "Science and Technology in an Unequal World."[1] This was an apt choice of topic. For on the one hand, throughout his active public life, Jawaharlal Nehru had been convinced that the key to initiating a comprehensive process of development lay in the application of the results of scientific and technological enquiry to the problems confronting Indian society.[2] Equally, Nehru was aware that India's own scientific and technological base could not provide more than a small fraction of the effort required to provide the solutions to these problems.[3] As the Prime Minister of Independent India, he was thus confronted with the task of identifying, and then accessing, foreign sources of technology. This was a task which raised complex issues, quite distinct from the technical problems of the "transfer of technology" from a foreign source to a local recipient.[4] While Nehru's experience as a nationalist politician might have provided him with an understanding of the power relations underlying the ground realities of international relations, the practical issues that might arise in the course of negotiating technology acquisitions could not be foreseen. It was through a condensation of the experience that India had accumulated in the twenty years since Independence that Blackett was led to the conclusion that the problems of enabling development in this "unequal world," through science and technology, raised generic issues worthy of special attention in a memorial lecture.[5]

The article that follows concentrates on a specific industrial project, and events that took place over a four-year period, between late 1950 and mid 1954. This was the period, as

the article attempts to show, when the contours of the post-war world order, both political and technological, began to impress themselves on the Indian political leadership. The defining features of the new world order, politically, were the formation of an integrated economic system consisting of the Soviet Union and the countries of Eastern Europe (the "Second World") and, simultaneously, the process of decolonization, which was to lead to the grouping of the "Third World" countries. Technologically, the specialized agencies of the United Nations, particularly UNICEF, UNESCO, and later the United Nations Industrial Development Organization (UNIDO) and the United Nations Conference on Trade and Development (UNCTAD) provided unprecedented means of access to scientific and technological knowledge. This new world order greatly expanded the range of options open to countries such as India. Major decisions of the subsequent period attempting the creation of a broad based program of industrialization, could now be taken with some degree of confidence as to the probable outcomes.[6]

As early as 1946, a year before Independence, the Government of India began to explore the possibilities of manufacturing pharmaceutical products, particularly those related to the prevention and treatment of communicable diseases. In 1946 and 1948, technical teams visited plants in Western Europe and North America and recommended the manufacture of Penicillin, Paludrine and three Sulfa Drugs.[7] In January 1949, the Government examined these recommendations and decided to set up a corporation in the public sector to produce these pharmaceutical products.[8] As the Government of India and the Government of the then Bombay State had jointly sponsored the project, the Government of India established, in April 1949, the Committee on the Penicillin Project to represent the interests of both governments. By the end of 1950, serious differences over the strategy to be followed led to the direct intervention of Jawaharlal Nehru.[9] This

intervention was to lead, as this article shows, to momentous decisions on the strategy underlying the acquisition of technology for corporations in the public sector.

II. The divide on technology strategy

In the early post Second World War period, Indian industrialists sought foreign technical collaboration in order to establish enterprises in new industrial areas. They were disappointed to find that this collaboration was not available without their granting some degree of ownership in the new firm to the foreign technology supplier. From their recent experience of colonial subordination, industrialists were unanimous in rejecting any substantial proportion of foreign ownership in their firms.[10] Fortunately for them, the Government of Independent India supported a policy of developing Indian owned and managed companies and introduced strict import controls to prevent the supply of foreign goods to the Indian market. When the threat of this "import substitution-based" industrialization became a reality in later years, firms in the advanced industrial countries faced the prospect of their products being excluded from the Indian market altogether. In this situation, they found it expedient to license their product and process know-how to Indian firms so that they retained some influence in the Indian market. Many Western firms were then prepared to license their technology without insisting on any ownership rights for themselves in exchange for royalties and lump sum payment. These agreements were always reached after hard bargaining and as there was no well defined market for technology, the outcome depended on the specific nature of the technology, on possible substitutes and, finally, on the relative negotiating skill of the two parties to the agreement.[11]

This strategy may be observed in the responses of Pfizer, Glaxo and Merck in the present case of the development of penicillin manufacture. In the early, relatively non-controversial, months of the Committee on the Penicillin Project, each firm offered marginal, though still important distinctions, in their proposals for collaboration. Glaxo merely agreed to import pure penicillin in bulk, and to use Bombay as a base for bottling therapeutic doses of the drug. Pfizer offered the Government the option of importing crude penicillin in bulk, to be refined and subsequently formulated.[12] Merck, one of the principle protagonists of this article, offered collaboration in establishing a manufacturing base, a major advance on the competing proposals, although the exact terms of the technical transfer process are not available.

While these negotiations were continuing, a new proposal for penicillin manufacture was suggested to the Government of India by UNICEF and the World Health Organization (WHO). This project, which envisaged the development of an antibiotic research and training centre linked to the penicillin manufacturing unit, represented not simply another manufacturing option. It challenged the prevailing wisdom on the feasible methods of establishing a manufacturing base, by demonstrating the possibility of accessing technical know-how itself, rather than depending on licensed production. This option had presented itself after K.C.K.E. Raja, the Director General of Health Services (DGHS) of the Government of India, had held initial discussions with UNICEF, after which the UNICEF officials had met the Penicillin Committee. As WHO were UNICEF's technical advisors, the Penicillin Committee were asked to obtain WHO's approval for their scheme. A memorandum was prepared and sent to UNICEF, while Raja agreed to take up the matter with WHO in Geneva. At this meeting, N. L. Macpherson of WHO told Raja that WHO could not recommend any project involving a commercial concern for UNICEF help. This effectively ruled out any collaboration for licensed manufacture. Macpherson

recommended that the proposed agreement with Merck Inc. be ignored, and gave an assurance that WHO could provide all the technical know-how and help.

Licensed manufacture had, by this time, become precisely the option preferred by industrialists, and the Government of India's decision to select Neville N. Wadia as the Chairperson of the Penicillin Committee was apparently made to ensure the representation of the interests of the major industrialists. Wadia, Chairperson of the family owned textile firm of Bombay Dyeing, had no obvious credentials for chairing the Penicillin Committee, beyond the fact that he was currently the President of the Bombay Millowners Association, the most cohesive and powerful bloc of industrialists.

Contrary to the view held by the WHO representative, Macpherson, G. Sankaran, technical advisor of the Penicillin Committee felt WHO's assurance had no firm basis, as no one in WHO had experience of working in a large-scale penicillin plant. In any case, Sankaran held that such persons would be unable to disclose information without a breach of faith, as they were bound to secrecy. Sankaran reiterated that it was essential to gain experience in working in a large-scale plant, and that it was necessary to collaborate with Merck. Raja suggested that Sankaran should be sent to Geneva to argue the technical points as he himself was not competent to do so. Although the Penicillin Committee agreed, permission from Nehru himself was required to go abroad on Government work. When Nehru was approached, he refused permission

Wadia felt that through this decision, the Penicillin Committee had been deprived of the opportunity of obtaining detailed information on the basis of which the Government of India could be properly advised of the relative merits of the Merck and UNICEF/WHO proposals. On the basis of this experience, Wadia felt that he could not work the project

in a business like manner anymore. He was therefore writing to Nehru to request him to intercede to ensure that the proposed organization which was to undertake the penicillin project was registered as a corporation in the public sector, where the Board of Directors was free to act, except in matters of major policy.[13]

This was a situation that Nehru would have presumably have wished to avoid. For if this proposal were accepted, the strategy favored by Bombay's big industrialists for establishing a manufacturing base through licensed collaborations might also set the pattern for corporations in the public sector. This pattern would then determine the degree of technical knowledge actually transferred in all future public sector projects

III. UNICEF and WHO enter the scene

A month later, the terms of the UNICEF/WHO proposal were made clear.[14] UNICEF would provide a grant to the Government of India of $850 000 for equipment for a penicillin factory, while WHO would contribute $350 000, also as a grant, for sending technical personnel to establish the factory. These personnel would design the plant, supervise erection and commissioning, establish the plant in operation, and train scientists, engineers and technicians. The Government of India was to agree that the plant would be free of links to commercial firms that might demand that manufacturing methods be kept secret, and to ensure that it would function as part of a group of international training centres in the field of antibiotics that UNICEF/WHO were in the process of establishing.

This information was first conveyed in a letter to Nehru by Santokh Singh Sokhey, leader of the two post war technical teams mentioned earlier, formerly Director of the Bombay-based Haffkine Institute, and at that time, an Assistant Director General in WHO.

According to Sokhey, the Penicillin Committee was wrong in their belief that the UNICEF/WHO proposal would mean a delay of a year. He asserted that WHO could complete the project faster than the Committee could do in collaboration with Merck. He pleaded that Merck should not be paid royalties, which would amount to at least $175 000 per year for 15 years. Also, that Neville Wadia who was in New York, presumably negotiating with Merck should be instructed not to commit India to an arrangement that would preclude UNICEF/WHO financial and technical aid.

In early December 1950, official confirmation of the UNICEF/WHO proposal reached Nehru directly from the WHO Director General, Brock Chisholm.[15] He confirmed that in addition to $850 000 from UNICEF for equipment, $350 000 would be available from WHO under the UN Technical Assistance Fund for providing technical personnel for plant design, erection, and commencing operation and for staff training. The penicillin plant was part of a worldwide UNICEF/WHO antibiotic program. It would be used as an international research and training centre, linked to a network of similar research centres in other countries. It was therefore essential that the plant should not be linked to any commercial firm that would demand that the processes be kept secret.[16] The assurance on this point given by the Government of India representative (Raja, Director General Health Services) had, in fact, influenced the Technical Assistance Board's decision to grant funds.

Continuing, the WHO Director General wrote that the argument that commercial firms were better able to provide superior technical knowledge was discounted by WHO experts. They felt that any slight improvement by one company would be matched within weeks by others. The new venture would, with growing experience, prove its own efficiency in the same way. Linked with the international research centres, the Indian

venture would also produce knowledge of value even to commercial organizations. The WHO Director General concluded his proposal by linking action on the UNICEF grant to a request from the Government of India to WHO asking for the complimentary aid.

IV. The Larger Considerations underlying UNICEF/WHO support

As Sokhey had surmised, the project was certainly symbolic of the role that United Nations' Agencies were staking out in the post war world. In a letter to one of his confidants, the Minister of Health, Nehru made it clear that he was not convinced that Merck was the sole supplier of particular patented processes.[17] He was sure that UNICEF/WHO must have competent people to advise the Government of India, or at the least, these advisors could themselves negotiate with Merck. As he was about to leave for England he advised the Minister of Health that though he felt that the Government of India could not refuse the WHO proposal, the decision should be taken after Wadia's return, without waiting for his own presence.

As the Director General of Health Services, Raja, the most senior technical official in the Health Ministry, was later to comment, Nehru's reply in December 1950 to the WHO Director General, Brock Chisholm, had virtually committed India to accepting the UNICEF/WHO proposal. If this was the case, then the question arises as to why, when both the Minister for Health, and the Prime Minister himself were in favor of UNICEF/WHO, it took the Government of India another four months to give a formal approval to the proposal. The answer lies in two factors, in the infirmities of the Patents Act as discussed in Section VI below, that allowed the pre-emptive filing of patents to prevent the growth of competitive manufacturing facilities; and the hostility to UNICEF/WHO displayed by the Chairperson of the Penicillin Committee, Neville Wadia.

In Sokhey's perception Wadia, who lacked the background knowledge of the technological implications for self-reliance underlying the two United Nations Agencies' initiative, was led astray by the salesmanship of the transnational pharmaceutical corporations. To counter these still potent influences, Sokhey intended to bring Nobel Laureate E.B. Chain (Professor of Biochemistry at the Instituto Superiore di Sanita in Rome) and N. L. Macpherson, the WHO Penicillin Team Leader to meet Nehru during his visit to London in early January 1951.[18] He felt that there was no purpose in writing letters to officials in Delhi who were indifferent to the issues involved.

V. The Contest: Transfer of Know-How vs. licensed manufacture

While Nehru was in London, Wadia returned to India with the terms on which Merck was prepared to collaborate. Learning of this, Nehru sent a telegram to the Finance Minister suggesting that no commitments should be made to Merck on behalf of the Government of India until a conference was held where the issues could be discussed and settled. The Finance Minister, C.D. Deshmukh, replied that while the advantages of the UNICEF/WHO offer were clear, there was a commitment to return the financial assistance in the form of free supplies of penicillin to WHO.[19] This obligation had to be weighed against the possible advantages of collaboration with a firm of Merck's reputation. He suggested that Sokhey should be invited to the conference in New Delhi where the merits of the two schemes would be finally evaluated. It was clear that the Finance Minister did not comprehend the larger issues that made the UNICEF/WHO scheme attractive to Nehru and the Health Minister

While the WHO Director-General Chisholm was not prepared to allow his officials to enter into debates with commercial firms, Sokhey was prepared to take the initiative to travel to India in early February 1951 to provide any information required. Telegraphing

his response to Deshmukh, Nehru said that he was convinced that the WHO offer must be accepted.[20] The project had the support of United Nations Agencies, who wished to use the production plant as a training centre linked to an international group of research laboratories. While the reputation of WHO was visibly at stake, as an organization it had no particular interest to promote. What was more, according to Nehru, the eminent scientists who first discovered the process of concentrating penicillin (presumably Howard Florey and E.B. Chain), and the people who built large production complexes and research laboratories, supported WHO. A Government connection with WHO would open up larger areas of collaboration for the country, making it an international centre for research and production. A significant indication of the prestige of UNICEF and WHO in these early post-war years was the commitment made by the United States' State Department to provide special priority for purchase and export of the capital equipment needed for the UNICEF/WHO project.[21] All that the United Nations' Agencies required of the Government was an open door scientific policy, and the free supply of penicillin to *Indian* children through publicly funded health programs.[22] Nehru pointed out that in the prevailing circumstances, India risked alienating the scientific world if, for any reason, collaboration with Merck was preferred. An indication of the possible repercussions was provided by the offence caused to senior WHO staff by a questionnaire that Wadia had sent to the organization. Particularly inappropriate, in Nehru's view, was the demand for a personal guarantee to be given by the WHO Director General on the performance of the penicillin plant.

With both Nehru and Sokhey in New Delhi in early February 1951, a series of Conferences were held between the most senior of the Ministers in the Government of India and WHO and UNICEF officials. In the course of preparation for the first of these conferences, it became clear to Nehru that the tenacity of the views against collaboration

with the United Nations' Agencies was due not only to differences over how penicillin was to be manufactured. It also signified that the implications of the project extended beyond the more general and critical issues of technology policy and the form of public sector intervention in industrial development. This was evidently the understanding that Nehru himself had held earlier.[23]

It was now clear to Nehru that UNICEF and WHO were organizations that drew their influence from the international support that they had from most of the countries in the world. Once organizations of this stature supported a project, there could be no question of their failing in the effort. There would be, in fact, considerable odium attached to the decision to refuse the WHO project. This consideration was reinforced by the strong reservations Nehru had against involving the Government in collaboration with large transnational corporations, especially in the sensitive area of pharmaceuticals.

It is significant that in two cases of large scale civil engineering projects, the Bhakra Nangal Dam in Punjab State, and the excavation of a tunnel linking Jammu with Srinagar in Jammu and Kashmir State, Nehru opted decisively for complete project control by foreign firms, or at least for the leadership of foreign engineering consultants. In significant contrast to his position on the penicillin project, Nehru wrote:[24]

> I am anxious and eager to help Indian firms and Indian engineers and technicians and not to have foreign firms undertaking major works in India where they can be dispensed with. But I am quite clear in my mind that the most important test is the experience of the firm and their technical competence. In relatively small projects special experience might not be needed, but in a large project that experience is of the first importance. If it is clear that the foreign firm has this experience and

> technical competence then I would choose that firm almost regardless of other factors.

While help could thus be sought for a particular scheme such as a river valley project or other similar projects involving complex *civil construction*, collaboration in a *manufacturing* enterprise, Nehru evidently felt, would imply political subordination on a continuing basis. This distinction was evidently based on the realization of the vast difference in the degree of technological knowledge possessed by the foreign technology supplier as compared to the Indian recipient in the case of the acquisition of manufacturing technology. Mere acquaintance with the successful operation of the manufacturing enterprise did not conclusively mean that this knowledge gap had been filled. In contrast, as long as Indians were included at senior levels in projects involving the creation of a technological artefact, such as a dam or tunnel, the knowledge could reasonably be expected to percolate to the Indians.

Nehru emphasised the reality: transnational corporations were "tough" and could well attempt to influence the directions of research that the Government of India wished its complex of research laboratories to undertake. At the most fundamental level was the consideration that: [25]

> We have built up a considerable number of laboratories and I have specially laid stress on research and the scientific approach, rather than the commercial approach to scientific problems. The commercial approach can pay dividends in a country like the U.S. where the whole basis of the social structure is commercial and individual profit making. We cannot emulate the U.S. in this and have to find a different way, a way in which the State takes a large hand and science has free play. To some extent, this

> free play of science is limited by the buying up of talent by commercial firms for their own advantage. We become parties to this latter process, if we try to develop under the aegis of a big foreign commercial firm.

The essential point here was that there was a distinction to be made between the research priorities set by the demands of an *industry*, and those set by an individual *firm* within the industry. The issue was further complicated if the individual firm was part of a transnational group, whose research priorities might be set by very distinct considerations. Concluding his letter to the Finance Minister, C.D. Deshmukh, Nehru remarked on the fact that during his visit to England, he had heard complaints at the most senior level of Government. These centred on the question of British autonomy in decision making having been curtailed by the compromises they had made with large transnational corporations from the United States. He was concerned that the planning process in India should be as free as possible from such externally imposed constraints. In a significant indication of his recognition that the industrialists did not all share this view, he ended by suggesting that the Government of India should disengage from the then Government of Bombay State. This latter Government was clearly being subjected to pulls in a direction contrary not only to his own vision of development of the pharmaceutical industry, howsoever critical this was, but to the very path of National Development itself.

On his return to Geneva from India in March 1951 Sokhey met Chain at the Instituto Superiore di Sanita in Rome. In a letter recording the results of these discussions, Chain emphasised that chemical microbiology was a new and expanding field of biochemistry, in which India had a right to expect to play a major part.[26] To do so, it was necessary that the research facility should be attached to an antibiotics production plant. Chain gave, in

the course of his letter, a significant indication of his understanding of the relationship between scientific research and the generation of technology relevant *know-how*. He stated that "…Production of antibiotics will stimulate research problems in all aspects of the field of chemical microbiology, and vice-versa, advances in research will be reflected immediately on the production capacity of the plant."

Chain continued in his letter to say "It is obviously essential that conditions be created in this research laboratory in which the Indian workers can carry out their tasks in a scientific atmosphere free from commercial secrecy and in close collaboration with scientists in other countries." These conditions could be ideally met if the Government of India accepted the UNICEF/WHO offer of collaboration, and "…cooperate [d] with the International Research Laboratories linked with WHO."

VI. Patents, Secret Processes, and Tacit Knowledge

The question of patents had arisen on various occasions in the course of consideration of the UNICEF/WHO proposal. With larger political considerations as expressed in Nehru's letter of early February appearing to favor the United Nations Agencies, the manufacturing processes to be used by WHO came increasingly under scrutiny. For Nehru and his Cabinet, there were three issues to be comprehended. The first was the distinction between a secret process and a patented one; the second was whether there was effective patent protection *anywhere* for the key processes involved in penicillin manufacture, and the third was whether patents filed under the existing Indian Patent law were legally enforceable. Chain dealt with the second and third issues.[27] The essential steps involved in the extraction of penicillin, which formed the basis for large scale manufacture, had been described in papers co-authored by him which dealt with the chemotherapeutic properties of penicillin, in *Lancet* and the *British Journal of*

Experimental Pathology, ten years previously. Chain did not think that any patents in the penicillin field were enforceable, though this would depend on the legal structure in specific countries. To the best of his knowledge no case had been upheld by the courts anywhere, though this was obviously a matter for patent lawyers to assess.[28]

Nehru was also able to get the advice of Edward Mellanby, Secretary of the British Medical Council, who was invited in March 1951 to India to be briefed on the issues, and to give his views.[29] For Mellanby, there were two major points for decision. The first was whether the WHO team led by Macpherson would be able to lead the penicillin project to successful completion. The second was whether the manufacture of penicillin was sufficiently well known and standardized, so that the scheme was unlikely to fail because of any ignorance of tacit elements of knowledge required to operate, maintain and quality control the production process. After a meeting in Bombay, Mellanby was confident that Macpherson could successfully complete the task, if he was the leader of the team.

Mellanby gave no details of how he had reached the conclusion that Macpherson not only had the competence to build a large scale penicillin plant, but had the ability to do so without infringing on any commitments to maintain commercial secrecy, a particularly critical issue given the post-war experience of British firms.[30] It will be recalled that Sankaran, Technical Advisor to the Penicillin Committee had raised precisely these issues in support of his recommendation that collaboration with a large scale commercial organization was the only feasible method of initiating penicillin production. However, the details of the wartime efforts to develop commercially viable methods of production and Macpherson's own earlier career provide the basis for comprehending Mellanby's confidence.

The development of commercially viable penicillin production processes was centred on the Northern Regional Research Laboratories of the United States Department of Agriculture, in Peoria, Illinois. These efforts, however, took place under war-enforced conditions of mutual pooling of the results of production oriented research within laboratories attached both to universities and to large corporations.[31] The Connaught Medical Research Laboratories at the University of Toronto were one of the two Canadian Organizations represented on the wartime research pooling effort and were included within the system of consultation and communication.[32] Before joining WHO in 1951 Macpherson had worked at the Connaught Laboratories as a Chemical Technologist and gained experience of large scale penicillin production. He had, in fact, been the chief initiator of the submerged culture process, including equipment design, at the Connaught Laboratories. According to a pamphlet published by the Connaught Laboratories, research had led to the development of a specific strain of mold, as also a method to crystallize penicillin by a unique method. Thus, although the Connaught production technology drew on the wartime work coordinated by the War Production Board, it had developed expertise in the entire production chain.[33] Sokhey and another colleague from the Bombay city based Haffkine Institute had, in fact, visited the Connaught Laboratories, and been trained there in the design of penicillin plants. [34]

Mellanby warned that the technical process of penicillin production was still full of snags. However, the problems were not insuperable and the project would have the advice of all those associated with WHO. Mellanby assessed that production in a plant established with Merck support might well progress more quickly and the product could be cheaper to the consumer, at least initially. However, Merck's onerous financial terms (royalty for 15 years and continued financial obligations even after that) did not seem worthwhile for penicillin production. For more complex chemotherapeutic drugs such as

paludrine, in contrast, Mellanby would certainly have recommended association with a western firm with experience in the process of synthesis of organic chemicals.[35]

Macpherson, through the mediation of Mellanby and Nehru, had managed to convince the Cabinet of the technological feasibility of the UNICEF/WHO proposal. However, during this same stay in Bombay where he met Mellanby and convinced him of his case, the meetings with the Penicillin Committee did not proceed satisfactorily.[36] According to a letter by Nehru to Sokhey in Geneva, the discussion did not cover precisely the points for which the meeting had been called, that is, the specifications of the processes that WHO intended to use. Nehru was mystified by Macpherson's reticence in the matter, and also frustrated by the inability to carry the State Government of Bombay along. The WHO representative's apparently inexplicable caginess had, all of a sudden, given new impetus to the opponents of the scheme.

During his stay in India, Macpherson had examined the patents that had been filed under the Indian Patents Act, which might possibly serve as a constraint on the UNICEF/WHO proposal to manufacture penicillin.[37] He found that, while the large majority covered processes that were not to be considered in the scheme he proposed, patents did cover four necessary processes. Of these, Macpherson was sure that in the case of one the patent was not applicable, in the case of two others he was doubtful, while in the last case, he considered that it definitely covered the penicillin manufacturing process. Inspite of these assessments, some members of the Penicillin Committee felt that more extensive use of patented processes would, in fact, be required. So, Macpherson was asked to specify the processes that WHO intended to use. These he was unwilling to do, on the scarcely credible grounds that there was a lack of time. This reticence infected the generally positive approach to the UNICEF/WHO proposal, and Nehru wrote to the

WHO Director General asking for his intervention on what was apparently a simple matter of more open communication. This hitch in finalising the proposal was also the occasion for the productivity of the WHO manufacturing process itself to be questioned. If it was less techno-commercially competitive than methods used by commercial corporations to make penicillin, the Government of India, Nehru indicated in his letter to WHO, wished to be free to improve the process through alternative, though unspecified, sources.[38]

WHO's response was as acerbic as a United Nations' Agency, of which the Government of India was a member, could afford to be.[39] It was pointed out that the problem had arisen as a result of the lack of co-operation by the Penicillin Committee. In fact, Sankaran, the Technical Member of the Committee had to be specifically instructed by the Finance Minister, C.D. Deshmukh, even to meet Macpherson. The letter from WHO admitted that it was true that the Secretary of the Production Ministry, A.V. Pai, had asked Macpherson to provide detailed specifications of the processes he intended to use. However, Macpherson met Pai, explained the situation to him, and was evidently able to satisfy him as to why "…the drawing up of specifications was not necessary." In the next section of this article, a hypothesis will be offered as to why Macpherson felt that this information could not be shared with the Penicillin Committee.

The letter from WHO continued with a discussion of the patents issue. The four processes, for which there was a possibility of a hitch because of one of the processes being covered by an existing patent protection under the Indian Patent Act, were further examined in Geneva by WHO's advisors on Macpherson's return in late March 1951. The patent application for the first of these processes, the use of corn steep liquor in the culture medium, was filed on September 25, 1945. However, on December 15, 1944, this

process was the subject of a lecture by Dr K.Ganapathi of the Bombay Haffkine Institute given at the Indian Pharmaceutical Association, subsequently published in July 1945 in the *Indian Journal of Pharmacy*. This instance of prior publication was held to invalidate the patent. In any event, WHO was considering using a synthetic medium rather than corn steep liquor for production in India.

The second process concerned the use of a precursor in the medium. This was the doubtful case in Macpherson's early estimation, because precursors were used in all processes of penicillin manufacture. However, it appeared that the patent holders were not the first discoverers of the process.[40] Several firms were known to be using precursors without paying royalties. In any case, as the substance used as precursor was a constituent of the culture medium, it was doubtful whether adding an extra amount qualified as a novelty.

The third process involved the use of butanol in crystallization. This had been published in the *British Medical Journal* in January 1945, and freely circulated in India almost two years before the patent application was filed in November 1946. Considerations of prior publication applied here, too, thereby invalidating the patent application. The fourth process concerned procaine penicillin manufacture. No patent was, however, valid for a substance resulting from the reaction of a base and an acid. Alternative methods were available, in any case, to produce procaine penicillin and the fourth Indian patent would not therefore be a hurdle for the commercial production of penicillin.

In this background, the WHO advisors were satisfied with the patent situation but were also consulting specialists in London on the matter. All other processes required for manufacturing penicillin were well known and details had been published. In WHO's

opinion, there was therefore no obstacle posed by the patents issue. On the question of productivity, WHO was categorical that using well known and publicly available processes, production could exceed the levels suggested by Merck several times, once sufficient experience with the manufacturing process had been gained in India. The letter from WHO of early April 1951 ended with a polite reminder that further delays in Government of India approval to the project could lead to the redeployment elsewhere of the UNICEF/WHO grant offered in December 1950.

Sokhey followed with his own letter a week later. He confirmed that patent attorneys in London, familiar with both the Indian Patent Act, and with penicillin manufacture, had given their opinion that the patents filed in India were not valid, and that "…no firm could extract royalties by bringing law suits."[41] He also addressed the question of the supposedly secret process that enabled Merck to claim substantially lower production costs, and to use that to justify the royalty of 3 to 5 million dollars (in then current prices) in total. As a representative of the Penicillin Committee, Sokhey had met in 1950 an official of the Swedish firm, Karnbogalet, with whom the Government of India was then negotiating for penicillin manufacturing technology. The claim made by this firm on behalf of Merck was, again, about a process of which Merck were not the originators. The originators, according to the representative of the Swedish firm, were two scientists of the University of Wisconsin at Madison. A paper describing the process had, in fact, been published in 1950 by the discoverers in the journal of "Industrial Engineering Chemistry" easily accessible in the Haffkine Institute library in Bombay.[42]

VIII. Private Capital's hidden agenda

There remained two points of controversy which required resolution before the Government of India could take a final decision on the merits of the UNICEF/WHO

scheme. The first lay in the processes that Macpherson intended to use, and the second lay in the actual production capabilities of the plant proposed. Raja, the Director General Health Services, was sent to Geneva to clarify the issues[43].

The most intriguing information that Raja provided was Sokhey's explanation for the uncommunicative behavior of Macpherson during his stay in Bombay. Sokhey asserted (and Raja felt it appropriate to "pass that on" to the Minister of Health and to Nehru), that Neville Wadia, as a capitalist, was on close terms with the management of both Glaxo and Merck. Not only would any information given to Wadia or the Penicillin Committee be given to these firms, but that the basis for Sankaran's queries to WHO was supplied by Glaxo.

There were a number of methods of crystallization involved in penicillin production. If any private firm wished to take the Government of India to court under the Patents Act, the onus of proving patent infringement would be on the firm. Under these circumstances, if Macpherson were to commit in writing to the processes he intended to use, this information would be crucial to the outcome of the case. Initially, Wadia, Chairperson of the Penicillin Committee had wanted Macpherson to provide the entire Committee with details of the processes he intended to use. Subsequently, he modified the position, and allowed Sankaran to meet Macpherson privately, in fact suggesting that if Sankaran were satisfied with the patent position, Wadia would himself support the WHO proposal. According to the earlier WHO letter written to Nehru explaining the patent situation, Sankaran had given the impression to Macpherson that he was more concerned with demonstrating the existence of patents, than in addressing the issue of whether they were, in fact, a barrier to the UNICEF/WHO proposal.[44] Sokhey went further in his talk with Raja in Geneva, and claimed that Sankaran, an official of the

Government of India, had entirely aligned himself with Wadia and the transnational pharmaceutical corporations. It was presumably with precisely this understanding that Macpherson had, throughout a three-hour discussion with Sankaran at the Taj Mahal Hotel in Bombay, refused to give any details.

IX. Production and Profitability

The second major issue of controversy was the actual production level from the proposed Indian penicillin unit. Merck claimed 600 000 mega units of penicillin a month using six fermenters, whereas the WHO/Macpherson figure was of 400 000 mega units per month capacity, also using six fermenters. Sokhey asserted, on the contrary, that with the use of the process described in published papers, and with equally commonly available strains of penicillin, 1800 units of penicillin per millilitre of the strain were achievable. Approximately 97 per cent of this was penicillin G. This translated into a production level of 750 000 to 1 500 000 mega units per month, much higher than Merck's production rate. Macpherson had specified the level of 400 000 units as a conservative figure, at which production costs would enable the penicillin to be sold at the prevailing market prices. [45]

Raja, the Director General of Health Services, who had been sent to Geneva to clarify the issues, elaborated on the basis for the WHO/Macpherson production figure.[46] In the proposed plant, there would be six fermenters, each with a capacity of 30 000 litres. Fermentation itself took about seventy-two hours, and an equal amount of time was estimated as necessary for cleaning the tanks and bringing them back into operational conditions, implying six days for each production round. Thus, in a month, there would be five rounds of production, and a yield from thirty fermentation tanks. Although the classical penicillin strain (Q 176) could give very much higher yields (as Sokhey had

suggested), a conservative figure of 700 units of penicillin per millilitre had been assumed in Macpherson's estimate. If, again, the operational capacity of each tank were assumed to be 25 000 litres, gross production would be 30*700*25 000, or 525 000 mega units per month. Assuming an extraction rate of 80 per cent, net production would be 420 000, or approximately 400 000 mega units a month. As experience was gained, the three days stipulated between each fermentation cycle could be appreciably reduced, and the number of cycles each month be correspondingly increased. At a figure considered reasonable, of forty-five fermentation tanks per month, production would be 630 000 mega units per month.

Raja obtained these details from Chain of the Instituto Superiore in Rome. Chain told him that Sankaran, the Technical Advisor to the Penicillin Committee, was insufficiently familiar with the actual process of penicillin production. Although Raja clarified that he was not quoting Chain verbatim, it seems that there was one essential point that Chain was attempting to convey to the Government of India. This was that the patent issue could not be a barrier to the UNICEF/WHO project as the essential knowledge on which the production of penicillin was based was the result of University based laboratory work and on collective work undertaken under the auspices of the War Production Board.[47] Equally importantly, Macpherson, through his association with the Connaught Laboratories was in the fortunate position of being free from commercial obligations of secrecy. At least one explanation for Macpherson's caginess was now available to the Government of India. Armed with this explanation and other, more technical, clarifications, the Government of India took a decision at the level of the Union Cabinet to accept the UNICEF/WHO proposal on 25 April 1951.[48] A formal agreement between the Government, UNICEF and WHO was subsequently signed in July 1951.

Under the plan, production was to have started in December 1953. This was delayed by about a year, the initial "seeding" of penicillin taking place in December 1954 and trial production starting in March 1955. Although production levels on a month-to-month basis fluctuated appreciably during the first year of operation, by July 1955 the targeted scale of production (400 000 mega units a month) was considerably exceeded, and production reached a level of 750 000 mega units in January 1956, and 890 000 mega units in February.[49]

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X. Conclusions

It was a signifier of the post Second World War situation that one of the two academic researchers, who discovered the process that substantially increased the productivity of penicillin production, while working at the University of Wisconsin, left the university to join Merck. Equally significantly, his colleague became a part of WHO's Expert Panel on Antibiotics. It was this kind of expert help that enabled the Government of India to navigate the shoals of obstacles to the acquisition of technology. On the one hand, there were assertions of economic independence by ex-colonial countries. On the other hand, there was the determination of industrial countries that this political independence should not lead to the loss of markets for technology, even if tariff barriers that accompanied import substituting industrialization strategies restricted markets for *commodities*. It would seem not unreasonable to view the question of patents in the case of the Penicillin project as an example of the pressures exerted by transnational corporations to retain existing markets for technology. The question was not confined to a single plant in India. After all, the vision of a research laboratory linked to a production unit on the one hand, and to an international network of research and training centres on the other, was not confined to the original UNICEF/WHO project document. It had also struck Edward

Mellanby, Secretary of the British Medical Council, as the best way to start an entire worldwide antibiotics *industry* "…. free from any private interest."[50]

However without the clarity that political experience over many decades had given Jawaharlal Nehru, the critical distinction between manufacture on the one hand and the creation of even the largest and most complex artefacts, on the other, might never have attained operational validity. It was the combination, then, of the immediate post war thrust towards internationalism, and the receptivity to these urges which had germinated during India's national movement that made the UNICEF/WHO project a potential exemplar of international cooperation.

The episode also brought to Nehru's notice the extraordinarily skewed focus of the existing Patent Law, which was geared more to maintaining a monopoly of manufacturing expertise in foreign patent filers' hands, than in providing reasonable rewards to innovators. It was through his direct experience with the problems posed by the penicillin project that, the following year, Nehru insisted that steps must be taken to modify the Act to ensure that India's industrialization effort was not needlessly entrapped in frivolous claims to priority in developing manufacturing processes. It was also entirely appropriate that both the Pharmaceutical Manufacturers Association, and the management of Hindustan Antibiotics, the successor to the Penicillin Committee, played a major role in the reconsideration of the patents legislation in India in the following years.

Note: All private papers consulted are available in the Archives of the Nehru Memorial Museum and Library, New Delhi. Except where expressly indicated otherwise, material refers to files containing Jawaharlal Nehru's personal papers, post 1947 series, first instalment.

[1] P.M.S. Blackett "Science and Technology in an Unequal World" in Jawaharlal Nehru Memorial Fund Jawaharlal Nehru Memorial Lectures 1967-1972 (Bombay, 1973): 1-22
Blackett's long standing association with Indian policies for science and technology are well explored in Robert S. Anderson "Patrick Blackett in India: Military Consultant and Scientific Intervenor, 1947-72. Part One" Notes Rec. R. Soc. Lond. 53 (1999): 253-273; "Patrick Blackett in India: Military Consultant and Scientific Intervenor, 1947-72. Part Two" Notes Rec. R. Soc. Lond. 53 (2000): 345-359 and "Empire's Setting Sun? Patrick Blackett and Military and Scientific Development of India" Economic and Political Weekly 36(2001):3703-3720

[2] Jawaharlal Nehru The Discovery of India (Calcutta, 1946) Section 10.9 "Religion, Philosophy and Science". These points are related to other aspects of Nehru's role as Prime Minister in Michael Brecher Nehru: A Political Biography (London, 1959) and Sarvepalli Gopal Jawaharlal Nehru: A Political Biography (Delhi, 1989)

[3] Ashok Parthasarathi and Baldev Singh Science in India: The First Ten Years, Occasional Papers in Perspectives in Indian Development, No. XXIV (New Delhi, Centre for Contemporary Studies, Nehru Memorial Museum and Library, 1992) (mimeo)

[4] Baldev Raj Nayar India's Quest for Technological Independence Volume –I Policy Formulation and Policy Choice Volume –II The Results of Policy (New Delhi, 1983)

[5] In 1968, the second of the United Nations Conferences on Trade and Development (UNCTAD) held in New Delhi signalled both the general recognition of the issue, and a process of formulation of guidelines to help countries similarly asymmetrically placed in the international market for technology.

[6] In the Indian case, this was most apparent in the substantially more ambitious objectives of the Second Five Year Plan (1956-61) as compared to those of the First Plan (1951-56).

[7] Estimates Committee Twenty Seventh Report 1955-56 Ministry of Production (The Hindustan Antibiotics Ltd. and The Hindustan Insecticides Ltd.) (New Delhi, 1956). Penicillin was then the best available anti infection drug; Paludrine was specifically for treatment of malaria and filaria, while the three sulfa drugs were developed to combat diseases of the respiratory tract and the intestines.

[8] As early as 1931, meeting for its annual session, the Indian National Congress had accepted the concept of "key" industries, critical to an overall process of industrialization, and mandated that enterprises in these industries should be owned or controlled by what was later characterized as the public sector. All these enterprises formed the "Public Sector" of Indian industry. Amiya Kumar Bagchi "Public Sector Industry and Quest for Self Reliance in India" Economic and Political Weekly 17 (1982): 615-628

[9] File No. 60, pp.201-4, Letter from Neville N. Wadia, 19 October, 1950

[10] Michael Kidron Foreign Investments in India (London, 1965) discusses the subsequent movement, of the change in Industry's attitude from "hostility" to "collaboration," in the period that follows the immediate time frame of this article.

[11] The implications for industry's technological performance of the strategy ultimately followed is detailed in K.K. Subrahmanian Import of Capital and Technology (New Delhi, 1972) and Nasir Tyabji Industrialization and Innovation: The Indian Experience (New Delhi, 2000)

[12] H K Mahtab Papers Subject File No. 20, volume 1, p.74, Letter No 943-PM, 14 July 1950 from Nehru to Mehtab; p.75, Letter DO No 197-HM/50 18 July 1950; p.107, Note by G. Sankaran 26 July 1950

[13] File No. 60, pp.201-4, Letter from Neville N. Wadia, 19 October 1950

[14] File No. 64, p.220, Letter from SS Sokhey, 18 November 1950

[15] File No. 68, pp. 252-3, Letter from DG WHO, Brock Chisholm, 6 December, 1950

[16] According to Paragraph 51 of the Report of the Executive Board of UNICEF apportioning $850,000 to the Indian Antibiotics Plant "The WHO also proposed that production plants receiving international assistance should be ready to exchange knowledge and personnel with other production centres and the International Research Group being developed by WHO. Stress was laid upon avoiding any situation which would lead to the production centre restricting information concerning any of its technical developments. Each production centre should essentially become a training ground for other plants." Appendix V in Estimates Committee Twenty Seventh Report 1955-56 Ministry of Production (The Hindustan Antibiotics Ltd. and The Hindustan Insecticides Ltd.*)* (New Delhi, 1956):40.

[17] File No. 68, p.254, Letter No. 1998-PM (Secret), 20 December 1950 from Nehru to Amrit Kaur

[18] File No. 70, p.55, Letter from SS Sokhey, 29 December 1950.
Ernst Boris Chain (1906-1979); began purification of penicillin 1943; played active part in research on production of penicillin by chemical synthesis; Nobel Prize with Alexander Fleming and Howard Florey 1945; FRS, 1949; Director, Research Centre for Chemical Microbiology, Rome, 1948; Prof. of Biochemistry, Imperial College, 1961-1973. [Source: *The Concise Dictionary of National Biography* (Oxford, 1992)]

[19] File No. 70, p.191, Telegram No 65 PSF5, 11 January 1951from C.D. Deshmukh, Finance Minister, to Nehru in London.

[20] File No. 70, p.240-242, Draft Telegram from Nehru to Deshmukh, copy to Amrit Kaur, 15 January 1951.

[21] In contrast, this permission was denied when Ernst Chain, after visiting plants in Eastern and Southern Europe, earlier supplied by the United Nations Relief and Rehabilitation Agency, suggested the introduction of Podbielniak separators, manufactured in the United States. Ronald W. Clark The life of Ernst Chain: penicillin and beyond (New York, 1985)

[22] In the agreement ultimately reached by the Government of India and UNICEF/WHO, Clause 8 of Section II would read "The Government will collaborate with the [World Health] Organization on technical process methods, to exchange knowledge and personnel with other production centres and the International Research Group being developed by the [World Health] Organization and to accept trainees from other countries."

Clause 10 of the same section read: "In accordance with the conditions set forth in the action of the Executive Board of UNICEF the Government will undertake to provide, free for distribution to children and pregnant and nursing mothers in India not less than $850 000 of penicillin computed at the cost of production, to be made available in five equal annual installments beginning one year after production reaches 400 000 mega units per month. Distribution will be made, as with other UNICEF supplies, on a Plan to be agreed between UNICEF and the Government." Joint Plan of Operations between the Government of India, the World Health Organization and the United Nations International Children's Emergency Fund for an Antibiotics Plant in India, reproduced as Appendix I in Estimates Committee Twenty Seventh Report 1955-56 Ministry of Production (The Hindustan Antibiotics Ltd. and The Hindustan Insecticides Ltd.) (New Delhi, 1956): 29.

[23] File No. 73, pp.56-60, letter from Amrit Kaur, Health Minister, to Nehru, 12 February 1951, and letter from Nehru to C. D. Deshmukh, Finance Minister, of the same date.

[24] File No. 266, p.51, Note No 310-PMO/54 of 5 July 1954, Prime Minister's Office

[25] File No. 73, pp. 58-60, Nehru letter to Deshmukh, 12 February 1951.

[26] JN Papers, 2nd instalment, correspondence file No. 278, letter 7 March 1951 to Sokhey, copy sent to Nehru with Sokhey's letter 21 March, 1951.

[27] Ibid.

[28] Although Chain was correct in writing that commercial production using the "surface culture" method amounted to a direct scaling up of the laboratory techniques used in the pioneering work at Oxford, it was not an accurate description of the contemporary state of commercial scale technology. Chain had not accompanied Howard Florey and Norman Heatly, another member of the Oxford Team which had collectively demonstrated the therapeutic value of penicillin, who in 1941 had travelled to the United States and Canada in order to generate support for developing methods of large scale production of penicillin. At these scales, as early as 1945, it had become evident that the method of deep fermentation in large tanks was far more efficient than the surface culture method used in the Oxford laboratory trials, and in scaled up production for war needs in England. National Academy of Sciences (U.S) The chemistry of penicillin; report on a collaborative investigation by American and British chemists under the joint sponsorship of the Office of Scientific Research and Development, Washington, D.C., and the Medical Research Council, London (Princeton, 1949), United States, Federal Trade Commission Economic report on antibiotics manufacture (Washington, 1958), Ronald Hare The Birth of Penicillin and the Disarming of Microbes (London, 1970), Lennard Bickel Rise up to life: a biography of Howard Walter Florey who gave penicillin to the world (New York, 1972), Selman A. Waksman The antibiotic era: a history of the antibiotics and of their role in the conquest of infectious diseases and in other fields of human endeavor (Tokyo, 1975), David Wilson Penicillin in Perspective (London, 1976), Gwyn Macfarlane Howard Florey: The Making of a Great Scientist (Oxford, 1979), John Parascandola (Ed.) The History of antibiotics: a symposium/ sponsored by the Divisions of History of Chemistry and Medicinal Chemistry, American Chemical Society Meeting, Honolulu, Hawaii, April 5, 1979 (Madison, Wisc, 1980), John C. Sheehan The Enchanted Ring: The Untold Story of Penicillin (Cambridge, Mass, 1982), Gwyn Macfarlane Alexander Fleming, the man and the myth (Cambridge, Mass., 1984), Trevor Illtyd Williams Howard Florey, penicillin and after (Oxford, 1984), Gladys L. Hobby Penicillin: Meeting the Challenge (New Haven, 1985)

[29] File No. 78, pp.65-66, letter 23 March 1951.

Edward Mellanby (1884-1955), Secretary, Medical Research Council 1933-1949; established vitamin D deficiency as main cause for rickets, 1919; FRS, 1925; expert in biochemistry and physiology; chairperson of International Conferences on vitamins and nutrition; concerned with schemes for wartime diet; Fullerian Professor, Royal Institution, 1936-37; First Director, Central Drug Research Institute, Lucknow, 1950-51 [Source: *The Concise Dictionary of National Biography* (Oxford, 1992)]

[30] Firms in England which had continued, under wartime imposed pressures, with large scale replication of laboratory procedures based on the surface culture method were driven in the post-war period to licensing the deep fermentation process from sources in the United States. Wilson (1976):227

[31] Richard I. Mateles Penicillin: A Paradigm for Biotechnology (Chicago, 1998): 9-10, John A. Heitmann and David J. Rhees Scaling up: Science, Engineering and the American Chemical Industry (Philadelphia, 1984)

[32] Hare (1970):173, R.D. Defries The First Forty Years, 1914-1955: Connaught Medical Research Laboratories, University of Toronto (Toronto, 1968): 192, R.D. Defries "Thirty-Five Years: Connaught Medical Research Laboratories, 1914-1949" (Toronto, 1949?) also published in Canadian Journal of Public Health 39 (1948): 330-44, R.D. Defries "The Connaught Medical Research Laboratories during the Second World War, 1939-1945"(Toronto, 1949?) also published in Canadian Journal of Public Health 40 (1949): 348-60

[33] This enabled the Laboratories to cooperate with the United Nations Relief and Rehabilitation Administration in training technologists from Czechoslovakia, Poland, Italy and the Soviet Union, and in providing working plans for the construction of plants, together with operational know how. Defries (1968):192-93.
Ernst Chain was subsequently commissioned by UNICEF to visit these plants and to suggest modifications and improvements in their functioning. Ronald F. Clark The Life of Ernst Chain: penicillin and beyond (New York, 1985): 101, 109, 118, 122, 125-6

[34] According to Sokhey's later account, this visit allowed sufficient expertise to be gained by him and a colleague to enable them to design the plant. The design was sufficiently well conceived for it merely to be endorsed by WHO. S.S. Sokhey "Self-Sufficiency in Modern Medicines- An Imperative Need" Economic Weekly, 9 (1958),Annual Number, January:

[35] The actual reason for Mellanby's recommendation was probably that he was aware that Macpherson had the capability to establish a penicillin plant. Similar "hands-on" experience, free of the constraints of commercial secrecy was not available in the case of other pharmaceuticals.

[36] JN Papers, 2nd instalment, correspondence file No. 278, Letter to Sokhey, 24 March 1951.

[37] File No. 78, pp. 95-96, letter 24 March 1951, from Nehru to Brock Chisholm, WHO Director General

[38] Ibid. A copy of the letter was sent to Sokhey, with the obvious intention that he should provide a means of liaison between WHO and the Government of India.

[39] File No. 79, pp. 330-333, letter from P. Dorolle, Deputy Director General of WHO to Nehru, 5 April, 1951.

[40] Dr Robert Coghill of the Northern Regional Research Laboratory, United States Department of Agriculture, Peoria reported the use of phenyl acetic acid for the first time in the *Restricted Monthly Report* No 16 of 20 November, 1943 sent to the Chairperson of the Committee for Medical Research, Office of

Scientific Research and Development. This Office had sent copies to all penicillin manufacturers, including the Therapeutic Research Corporation, the Indian Patent holders. Under these circumstances the patent holders were not likely, in WHO's opinion, to file a suit over a process that they had not originated, and bring themselves into ridicule.

The Therapeutic Research Corporation consisted of a grouping of the main pharmaceutical firms in Britain formed under wartime pressure for pooling research efforts. David Wilson Penicillin in Perspective (London, 1976):222.
These firms included Boots Pure Drug Company, British Drug Company, Glaxo Laboratories, May and Baker and Wellcome Laboratories. See Roland W. Clarke The life of Ernst Chain: penicillin and beyond (New York, 1985): 75

[41] File No. 82, pp.84-86, letter to Nehru, 11 April 1951

[42] Ibid. The claim was that Merck's used a strain of penicillin that gave a higher yield, and a slightly modified medium. As a result, both the yield and the fermentation time were doubled. The rate of extraction was improved because the broth was more concentrated. Although the yield per unit time was little different, the cost of the raw material, the most expensive item in production, was halved.
This process had, in fact, been discovered and published by W.E. Brown and W. H. Peterson of the University of Wisconsin in 1950. Peterson was currently an advisor to WHO for penicillin. The paper, presented before the Division of Agriculture and Food Chemistry at the 116th meeting of the American Chemical Society, was published in Industrial and Engineering Chemistry 42:1769-1774.

[43] File No. 82, pp.87-92, letter from K.C.K.E. Raja to Amrit Kaur, 17 April 1951. Raja considered the contents of this letter sufficiently controversial to require him to write it by hand, and in pencil, so as to obtain a carbon copy!

[44] File No. 79, pp. 330-333, letter from P. Dorolle, Deputy Director General of WHO to Nehru, 5 April, 1951.

[45] File No. 82, pp.84-86, letter to Nehru, 11 April 1951

[46] File No. 82, pp.87-92, letter from K.C.K.E. Raja to Amrit Kaur, 17 April, 1951.

[47]Chain and Sokhey went further. They "ridiculed" Merck's stipulation that the effluent from the plant they proposed should be treated to destroy the penicillin strain they had offered to provide, "…. as a commercial stunt to make the unwary and uninformed accept the fact that they possess a superior strain."Ibid.

[48] File No. 82, pp.296-299, Draft minutes of Cabinet meeting No. 1223/CM/51, 27April 1951.

[49] Estimates of the quality and of the degree to which production was competitively organized are more difficult to establish. An indication of the intense competition in the international market for penicillin is provided by the fact that there were 12 reductions in price between 1951 and 1954-55, and even deliberate dumping of penicillin in Indian cities. The Estimates Committee of the Lok Sabha reported that procaine penicillin was available in India at about a quarter of the price in the United States and about half the English price. Under such distorted market conditions it is difficult to evaluate the implications of the sale of a consignment of Indian made penicillin at international prices which were reportedly a little less than the estimated cost of production. Estimates Committee(1956): 5,11
See, also, US Senate, Committee on the Judiciary, Subcommittee on Antitrust and Monopoly, 86th Congress, 1st Session Hearings on Administered Prices, Part 14 and 87th Congress, 1st Session, S. Report No 448 Administered Prices: Drugs, Estes Kefauver In a few hands; monopoly power in America (New York, 1965)

[50] File No. 78, pp.65-66, letter 23 March 1951.