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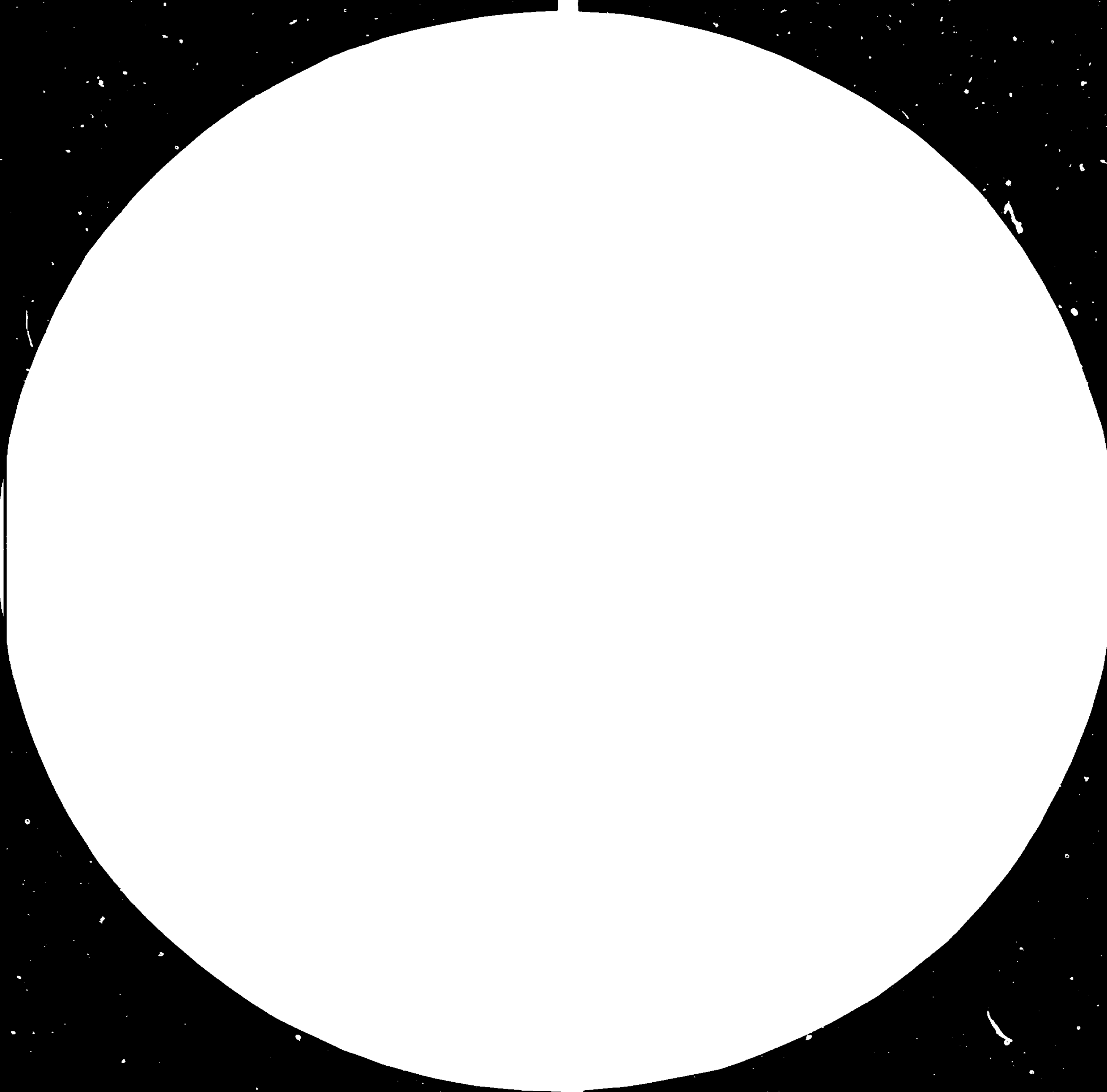

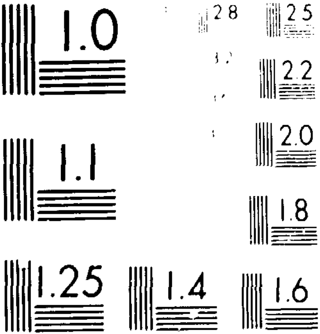
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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

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Development and Transfer of Technology Series

No. 14

CASE-STUDIES IN THE ACQUISITION OF TECHNOLOGY (I)

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UNITED NATIONS

CASE-STUDIES IN THE ACQUISITION OF TECHNOLOGY (I)

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna

Development and Transfer of Technology Series No. 14

CASE-STUDIES IN THE ACQUISITION OF TECHNOLOGY (I)

UNITED NATIONS
New York, 1981

Preface

The present publication in the *Development and Transfer of Technology Series* is an attempt to provide the reader with a fairly detailed description of actual cases of successful and unsuccessful transfer of technology both from industrialized to developing countries and among industrialized countries. However, details of actual partners and products have been changed in some of the cases.

The cases described include not only the background information leading both future partners to initiate and conclude negotiations, but also the course of negotiations and the outcome in the form of an agreement. In some cases, however, it was not possible to reproduce full agreements; therefore only general descriptions of the terms agreed upon have been given.

The publication is designed for the licensing manager in the enterprise or government officials dealing with technology transfer issues.

It is intended in the future to release a second volume of case-studies.

EXPLANATORY NOTES

References to dollars ($) are to United States dollars unless otherwise stated.

References to pounds (£) are to pounds sterling unless otherwise stated.

A slash between dates (e.g., 1956/57) indicates a crop year, financial year or academic year.

Use of a hyphen between dates (e.g., 1956-1958) indicates the full period involved, including the beginning and end years.

A full stop (.) is used to indicate decimals.

References to tons are to metric tons, unless otherwise specified.

The following notes apply to tables:

Three dots (. . .) indicate that data are not available or are not separately reported.

A dash (–) indicates that the amount is nil or negligible.

A blank indicates that the amount is not applicable.

Thousands, millions etc. are set off by spaces unless a symbol for a monetary unit precedes the number.

In addition to the common abbreviations, symbols and terms and those accepted by the International System of Units (SI) the following have been used:

c.i.f.	cost, insurance, freight
crore	10 million
DPR	detailed project report
ERW	electrically resistance welded
lakh	100 000
latcha	1 million
MHD	magneto-hydrodynamic
NC	numerically controlled

Organizations

BHEL	Bharat Heavy Electricals Ltd.
CMEA	Council for Mutual Economic Assistance
CPU	Committee on Public Undertakings (India)
HPF	Hindustan Photo Films Manufacturing Company Ltd.
3-M	Minnesota Mining and Manufacturing Company
NIDC	National Industrial Development Corporation (India)

CONTENTS

I. The licensing of high-temperature measurement equipment

*John Gay**

Background

In 1955-1957, the LMN Corporation, Los Angeles, California, United States of America, developed a pyrometer for high-temperature measurement. As part of a deal with ABC Ltd., manufacturers of chemicals, Manchester, United Kingdom of Great Britain and Northern Ireland, LMN Corporation gave ABC a non-exclusive world-wide licence on terms to manufacture the LMN high-temperature measurement equipment. ABC exploited the LMN pyrometer very successfully and over the years built up for itself a world-wide reputation in this field.

In 1963, XYZ Ltd., a United Kingdom company operating petroleum refineries, developed a novel bimetallic thermocouple that was small and cheap to manufacture. With the use of simple indication circuits, this thermocouple made it possible to measure a higher range of temperatures more cheaply and accurately than any other pyrometer on the market, including the ABC pyrometer. The only difficulty lay in the design of the thermocouple, which infringed claims of the LMN United Kingdom patent under which ABC had a licence. After discussions among ABC, XYZ and LMN, it was decided that ABC should manufacture the improved XYZ thermocouple and incorporate it in its standard range of temperature measurement equipment. Further, XYZ would be licensed to use its improved pyrometer for its own purposes on nominal terms. This case-study describes the way in which the thermocouple development by both LMN and XYZ was exploited to the satisfaction of all parties.

LMN Corporation

LMN was formed in 1948 to manufacture non-ferrous alloys principally for the aircraft industry in southern California. From simple beginnings, it is now a substantial company with a turnover, in 1976, of $200 million, still mainly in non-ferrous alloys. Recently, it added the production of master alloys (alloys that only require "diluting" with other metals to form the required alloy). In addition to the original factory in Los Angeles, now also the company headquarters, it has a corporate development laboratory in San Diego, California, a manufacturing plant established in 1954 near Albany, New York, and a wholly owned subsidiary, formed in 1973, in the Federal Republic of Germany. LMN GmbH initially factored much of the LMN range of products in Europe. Within the last two years it has started to manufacture certain LMN alloys as well. The turnover of the company in the Federal Republic of Germany is now about $20 million, just less than 10% of the LMN group turnover. LMN has been glad to have this business in the last few years when selling has become more difficult in the United States.

LMN has grown steadily since 1948. Its research and development laboratories have become adept at anticipating United States alloy requirements, particularly for the aircraft industry. While it has taken a few licences for particular products, its expansion has, in the main, been based on its own development.

LMN found that there was no temperature measurement equipment available that was capable of measuring to the accuracy and over the range it required, particularly for use with the furnaces in which certain of its alloys were manufactured. Using its knowledge of alloys, LMN therefore established a research and development programme to develop better thermoelectric materials, which in combination with suitable industrial electronics should enable it to produce pyrometers to the required specification. LMN filed patent applications on this pyrometer in the United States, the Federal Republic of Germany and the United Kingdom, with a priority date in January 1956. The claims related to the design of the thermocouple incorporated in the pyrometer and the application of the thermocouple to a pyrometer itself.

Around 50 of these instruments were subsequently manufactured by both LMN and a local subcontractor for use on LMN furnaces. At that time LMN paid its subcontractors about $500 to manufacture each set of electronics to which it added the bimetallic thermocouple element contained in a

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high-temperature sheath (both components made by LMN). After a few teething troubles, the complete pyrometer worked well.

LMN considered manufacturing and selling its design of pyrometer, but came to the conclusion that such diversification would distract the company from its main business of making and selling alloys. Additional staff with new skills would be required for manufacturing the pyrometers; more salesmen would have to be employed to handle them, since men selling alloys would not have the requisite experience. LMN therefore decided to keep its invention to itself and use it for its own purposes, at any rate until its patents were granted.

In 1957, LMN started purchasing pure chemicals from ABC Ltd., Manchester, for use in its alloy production. Although the quantities were initially small, ABC provided an excellent service and was prepared to ship to LMN even small consignments of 50-100 lb of the materials LMN required, since at that time ABC was engaged in exploring the United States market for specialized chemicals and saw LMN as a good potential customer. As part of ABC's investigation of the United States market, its overseas manager, Mr. Smith, visited LMN in April 1959 to meet the LMN management and judge whether sales with LMN were likely to increase and if so by how much. As often happens in cases of this kind, Mr. Smith and the LMN production manager using the ABC products, Mr. Dorsky, got along well, and Mr. Smith was invited to look around the LMN factory. During his visit Mr. Dorsky showed Mr. Smith the LMN pyrometer, although no details of how it had achieved its outstanding performance were disclosed.

After the visit, Mr. Dorsky reported to his superior that Mr. Smith had shown great interest in the new pyrometer. LMN officials were impressed with Mr. Smith and his willingness to travel so far to see them as well as with what he had told them about ABC (which corresponded with the report on ABC that LMN's bank had obtained before Mr. Smith's arrival). As a result of Mr. Smith's visit, LMN officials felt their decision to work with ABC had been justified, and they decided to place larger orders for pure chemicals with ABC and also to inquire about the possibility of ABC's manufacturing special products not shown in the ABC catalogue. In July 1959, LMN received a letter from ABC expressing its willingness to supply the ABC range of pure chemicals to LMN on a basis satisfactory to both of them. The letter also inquired about the possibility of manufacturing the LMN pyrometer.

ABC company

The ABC company was established in 1939 by two chemists. The company prospered, developing and manufacturing a range of organic products and catalysts for use in high-temperature processes. By 1955, when the company changed its management, it had a turnover of around £10 million, still largely in the original fields.

In 1957 a somewhat old-fashioned scientific instrument company in Manchester came on the market. It had a turnover of about £500,000, was barely profitable and manufactured a rather out-of-date range of pressure and temperature measurement equipment and laboratory instruments used mainly for schools. The new directors of ABC bought the assets of this company believing that diversification would enable ABC to grow at a faster rate than in previous years. These assets, for which ABC paid £50,000, consisted of a freehold building, written-down machinery and a certain amount of work in progress. After selling the building for £25,000, ABC established an instrument division into which the remaining assets of the scientific instrument company were put. By cutting out the unprofitable products and making a great effort, the turnover of ABC's instrument division slowly picked up, and by 1959 it had reached a profitable £700,000.

The new directors of ABC also considered how the company's traditional product could be expanded. As a result, Mr. Smith, the expert sales manager, was appointed. His advertising campaign, together with extensive overseas visits, led to an increase in sales of pure chemicals to LMN and his visit there as previously described. Thus, ABC heard with great interest about the LMN pyrometer and the possibility of higher product sales to LMN.

Preparation for negotiations by LMN and ABC

LMN considered the following points in deciding whether to enter into a licence agreement with ABC:

(a) It had decided not to proceed with the commercial manufacture and sale of its pyrometer, although it wished to continue using the pyrometer for its own purposes;

(b) It was not LMN policy at the time to seek a return from this sort of product, other than the advantage of being able to use the product;

(c) It was not keen to devote technical time to finding and supporting a licencee, since this would bring unwanted visitors to its plant;

(d) It recognized the worth of the ABC products and considered that the granting of a licence to manufacture its pyrometer would cement relationships and enable it to obtain ABC products at reasonable prices;

(e) So long as payment of royalties ultimately paid for the cost of developing the pyrometer, it was not particularly worried about royalties, although it recognized that a successful licensee in Europe could return LMN up to £50,000 per annum from this market;

(f) While it was prepared to be open-minded about entering into an agreement, it considered that it ought to get the best deal possible. Therefore, although it had, at the time, no intention of granting further licences, it decided to resist any request from ABC for exclusivity; it would also seek to maximize its return by assessing royalties not only on the pyrometer it had developed, but also on the complete temperature measuring equipment;

(g) It also decided to ask ABC to purchase thermocouple elements, if not the complete device, comprising thermocouple and sheath, from LMN, certainly in the initial years of the agreement. The patent agent advised LMN that this request could not be made a condition of the agreement, but that did not worry LMN unduly, in view of its increasingly close relationship with ABC;

(h) Much depended on the strength and ability of ABC, and LMN therefore instituted checks on ABC through its bank; it also asked the United States embassy in London for its opinion. Further, it arranged for one of its vice-presidents, who was to visit the United Kingdom, to visit ABC and judge whether ABC would be able to manufacture and sell the pyrometer successfully.

ABC viewed the proposal to manufacture the LMN pyrometer as follows:

(a) It accepted that, potentially, its pure chemical sales to LMN would be of greater importance to it than the sales of the ABC pyrometer. It would not therefore wish to fall out with LMN over the terms for manufacturing the instrument, but equally it would not accept unduly onerous arrangements;

(b) ABC recognized that the LMN product was exactly right for it and would help appreciably in putting its instrument division on its feet. ABC was therefore keen to get the rights on it;

(c) With its aim of substantially increasing exports, ABC would want world-wide manufacturing and selling rights, preferably on an exclusive basis, although it recognized that LMN would have to be permitted to manufacture the pyrometer (or have it manufactured) for LMN's own purposes;

(d) While ABC believed that there was a reasonable market for the LMN pyrometer, it nevertheless decided to ask Mr. Smith to carry out a United Kingdom survey. It would not be worth ABC's while to manufacture the LMN pyrometer unless sales in the first year or two of at least £100,000, and subsequently much more, could be anticipated. The survey revealed a market of around £3 million for this type of instrument, in respect of which ABC thought, conservatively, that it could obtain an initial 5%-10%. From the market point of view, therefore, ABC felt encouraged in its consideration of the LMN pyrometer;

(e) The ABC production manager for the instrument division emphasized the need to ensure that LMN's information about its pyrometer was readily available and in a form suitable for ABC. He asked whether ABC would have to make many changes in the LMN drawings or have difficulty in getting the component parts of the pyrometer, even though ABC accepted that LMN would probably wish to supply the thermocouple itself, and whether LMN would give some help in setting up production;

(f) ABC's manager also raised the question of improvements made by LMN. LMN, with an increasingly large research and development department, would almost certainly improve its pyrometer in years to come, which would be very valuable. It therefore resolved to discuss this point with ABC;

(g) The ABC production manager looked into the likely costs of making this new product. Mr. Smith had been told that the pyrometer and electronics cost LMN about $600, which would indicate a manufacturing price in the United Kingdom of about £200 and a selling price of £400-£500, certainly initially. (ABC generally worked on 100% on cost to cover sales administration and profit, usually set at 25%.) ABC would therefore have to manufacture 200-250 pyrometers per annum to meet its self-imposed target, and this seemed possible. These figures would have to be refined when ABC received more information from LMN, but on the basis of the details available, ABC thought it could make and sell the LMN pyrometer profitably. As to royalties, ABC saw no particular problem about paying 5%-7.5% on the selling price after the cost of packaging, insurance and transport of the finished goods had been deducted. Obviously, this cost would have to be kept as low as possible, but it also recognized the value of having LMN as a customer for its pure chemicals. ABC therefore decided to get the best deal it could short of antagonizing LMN and wrote LMN accordingly.

The LMN-ABC negotiations

The companies met in September 1959 in Los Angeles. The excellent relationship established by Mr. Smith of ABC earlier in the year was maintained, and both parties quickly concluded that they should try to make a reasonable deal if possible. Although ABC had received some information from both Mr. Smith and LMN on the LMN pyrometer, the first day or two of the visit was spent in looking at the LMN product and the associated information, particularly the drawings, available models and costing. ABC noted that some materials, particularly electronic components, would not be readily available in the United Kingdom, and it accordingly gave some thought as to how it would obtain them. LMN confirmed it would want to supply the thermocouple itself, and this was acceptable to ABC, subject to a reasonable price being charged and ABC being assured of a continuing supply. After some discussion, LMN proposed a satisfactory price structure on the thermocouple itself, including the sheath for two years ahead: and LMN also over the first two years, agreed to supply the thermocouple assembly in smaller batches (5-10) than would really be economic for it. Thereafter price and supply would be subject to discussion. These arrangements would enable ABC to avoid having to order large numbers of thermocouples at one time with no certainty, at any rate initially, that they would be sold. The discussions centred around a few points, discussed below.

Supply of ABC product and termination of the licence agreement

ABC realized that obtaining a written undertaking from LMN to purchase agreed quantities of its materials was probably not practical. There were also other suppliers, and ABC could really rely only on the good quality of the products it sold, its willingness to give LMN a good service and close personal relationships between senior and middle management in the two companies. Since Mr Smith had got along well with LMN, ABC decided that he should be its principal day-to-day contact, but the two new managing directors of ABC also resolved to make yearly visits to LMN.

For its part, LMN thought highly, so far, of ABC, but it was by no means prepared to rely on ABC. If quality and price were right, it would be prepared to purchase from ABC, even to the extent of giving ABC orders for several years ahead. But it would ensure that these related only to a part, perhaps an increasing part, of their requirement. It would look to some price advantage from ABC and a "special" customer relationship, but it did not expect any difficulty in this respect.

LMN recognized that the granting of a licence on its pyrometer could hardly be made conditional on ABC's providing materials to it in a satisfactory manner. Nevertheless, it resolved to incorporate into any agreement some degree of flexibility permitting it to transfer the licence if it was dissatisfied with ABC's performance, both in the manufacture of thermocouples and the supply of pure chemicals.

In the event, both parties agreed that the supply of ABC products should be kept separate from the pyrometer licence. LMN obtained the right to terminate the licence agreement on giving 30 months' notice (it wanted 12 months but in the end agreed to the longer period when ABC argued that it might have to run down stock and sell off part-manufactured products as well as find a replacement product, all of which would take longer than 12 months).

Financial payments in the licence agreement

Discussions on payments took much longer than either party expected. LMN was not prepared to give the licence away, and having also looked at the market for pyrometers in the United Kingdom and Europe, it realized that ABC would probably do very well. LMN had not prospered by ignoring even small sums of money such as this; and knowing the manufacturing costs and likely selling prices of its pyrometer in the United Kingdom, it considered that ABC should pay a royalty of 10% of the selling price, which it defined (and this became important at a later stage in the life of the agreement) as the price of the thermocouple itself and associated electronics and equipment. Its aim was, of course, to cover for royalty purposes the thermocouple and its high-temperature ceramic sheath, and also the associated electronic amplifiers that it had built to work with the thermocouple. ABC very reluctantly accepted this proposal, although it realized that a 10% royalty was not really crippling in view of the estimated margin between the cost of manufacture and the likely selling price of the complete instrument. ABC did, however, persuade LMN to relieve it of royalty payments for the thermocouple itself where this was provided by LMN in the first two years of the agreement. Both LMN and ABC accepted there were constraints on both of them in making the supply of the thermocouples a condition of continuing the agreement, and this point was not even raised.

Exclusivity

LMN was reluctant to grant any exclusivity, but it informed ABC it had no intention of granting further licences in the United States, United Kingdom or elsewhere in the immediate future, although much would depend on ABC's performance. Both parties understood that LMN would not appoint another licensee so long as ABC continued to provide its products to LMN in a satisfactory manner. ABC was prepared to accept the implied challenge, and the parties agreed that the arrangements would proceed on a non-exclusive basis.

The First Agreement

Having dispensed with the three major points above, both parties agreed that the LMN legal attorney should prepare a draft agreement for their consideration. Both hoped that the details could be settled by post, since travel between Los Angeles and Manchester took quite a long time and in LMN's view hardly justified the expense involved. Some correspondence was exchanged about making improvements introduced by LMN available to ABC, but in the end ABC had to accept that these would be given to ABC if LMN was, once again, satisfied with other aspects of their relationship, particularly the supply of fine chemicals and the manner in which ABC exploited the LMN pyrometer. The agreement (the First Agreement) both parties signed in January 1960 is shown in annex I.

ABC quickly discovered that the LMN pyrometer was an excellent product. Some difficulty was found (as always) in translating the LMN drawings into a form suitable for use by ABC workers; and, initially at any rate, the supplies of thermocouples from LMN took some time to arrive from Los Angeles. However, with greater confidence in the product, ABC felt sure enough of its market to order thermocouples from LMN in greater numbers so that it always maintained a reserve of them. It was also not easy to get electronic components in the United Kingdom comparable to those used by LMN. Eventually, however, ABC found a suitable source of these; and by making modest changes in the design of the amplifier circuits in particular, it was able to produce equipment that worked well and somewhat more reliably than the LMN model.

LMN had, of course, designed the pyrometer for its own use; and although the equipment was well made, it was hardly eye-catching. While not altering the basic design, ABC therefore decided to improve the exterior of the pyrometer, particularly the cases in which the electronic circuits were contained and the associated front panels, to bring the exterior design of the instrument up to contemporary standards. This it did during the spring of 1960, and by May the ABC pyrometers were ready for sale.

ABC decided to announce the new instrument at a trade exhibition in London in June 1960. The response from attendant press publicity confirmed that it had been wise to obtain a licence on the LMN product, even though the terms of the agreement were more severe than it would have wished.

With a somewhat higher royalty and more mechanical design to do than ABC had expected, manufacturing costs of the complete instrument came to nearly £400, which was more than earlier estimates. Bearing in mind the competition and the willingness of customers to pay some premium, but not too much, for improved performance, ABC decided to put its instrument on the market at £750.

In the first year, ABC manufactured just over 100 of the LMN pyrometers, not as many as had been hoped, but nevertheless a very satisfying beginning to the exploitation of its new instrument. In the second year, production increased by some 160 instruments with a few being sold overseas, including in the United States. By this time ABC was well content with the arrangement with LMN, since sales of pure chemicals were also going well. Mr. Smith's original visit to LMN had obviously borne fruit.

In 1962, ABC added a small recorder to its temperature indication instrument. Since the agreement provided that royalties should be paid on pyrometers, including associated electronic equipment, ABC's financial director considered that a recorder, in those days mainly of mechanical design although operated by electronic impulses, was not "electronic equipment" and therefore no royalty should be paid to LMN on it. However, since relations remained close between the two companies, ABC decided to check this point with LMN.

LMN replied quite promptly that in its view a recorder should be regarded as "electronic equipment". It informed ABC that its research and development laboratory in San Diego had redeveloped part of the amplifier unit and it was prepared to pass the new information on to ABC if ABC would regard this information as having been passed under the terms of the 1960 agreement. Since ABC had no alternative, it marked up the price of the recorder to include the handling charge of 15% and the royalty of 10%—not so bad as it sounded, since ABC purchased the instrument in bulk at a 20% discount, and thus the price of recorders to ABC customers was not very different from the normal selling price. In particular, the slight increase in price, when viewed against the price of the pyrometer, was not enough for a customer to take the trouble of purchasing a separate recorder.

ABC also decided to accept the offer of the information on the improved amplifier unit and agreed that the information would be considered to have been transmitted under the First Agreement.

Sales increased satisfactorily. With the LMN improvement and some advances that ABC made, the ABC pyrometer secured an increasing share of the market. Overseas sales increased, too, and by 1964 ABC was selling 400 pyrometers per annum at an average United Kingdom price of £1,000, excluding recorders. LMN, too, was pleased with the steadily increasing royalties from ABC.

In November 1965, LMN received a letter from the United Kingdom headquarters of XYZ informing it that XYZ had filed a United Kingdom patent application and corresponding patent applications in certain overseas countries, including the United States, on an improved thermocouple and asking whether LMN would be interested in it.

XYZ Ltd.

XYZ Ltd. is a major refiner of petroleum products in the United Kingdom. Although it has associated companies in some other countries, including the United States, one of its two corporate research and development laboratories is located in the United Kingdom, in part to service its considerable refining capacity there. The laboratory programmes in the United Kingdom cover the whole range of applied research and development in the petroleum field. These laboratories have, for example, extensive facilities for testing new processes in pilot plants, including the development of new materials such as catalysts. These facilities are available for hire by other companies, particularly those that may want to use them to develop new products for ultimate sale by XYZ Ltd.

As part of its research and development activities, XYZ develops much of its own instrumentation and has since the early 1950s made a significant contribution to transducer design for measuring parameters such as flow, pressure and temperature. In the last 10 years its attention has turned to automation. As a result of the large teams it has employed in this area, XYZ has been able to introduce in its plants very advanced instrumentation systems for control purposes. It has made rapid strides in the use of digital techniques. After its own requirements have been met, XYZ has licenced some of its instrumentation mainly to United Kingdom companies manufacturing advanced control equipment. In view of the significance of licensing for XYZ, it maintains a large patent and licensing department.

Accurate high-temperature measurement has always been important for XYZ. Initially, through reports from its United States associated company of meetings with LMN executives, XYZ became aware of LMN's pyrometer work; but since LMN did not itself put its equipment on the market immediately, XYZ was denied the use of the new equipment until ABC started to sell it. XYZ found the ABC pyrometer useful, and from 1961 on it ordered a number regularly.

By 1963, however, XYZ found that it needed to measure accurately temperatures in the range of 1,300°-1,500°C; and although the ABC pyrometer would operate at those temperatures, its accuracy was far from satisfactory. By that time, too, ABC had added a recorder and had meter indication of temperature as well; and it started to supply the thermocouple, amplifier, indicator and recorder as a complete entity, which, unless quite large numbers were ordered (about 50), it was not prepared to sell except–as a complete unit. XYZ had little use for the recorder, since it was connecting the ABC instrument to an automatic recording system of its own design. ABC, however, was most reluctant to supply only thermocouple and amplifier units, and XYZ therefore either had to order large numbers of individual components or purchase smaller numbers of an instrument having (for it) unnecessary features. It therefore resolved to consider designing itself a simple instrument operating over a higher range of temperatures than the ABC model and having greater accuracy. XYZ started this development at its instrumentation laboratory in 1963.

Technically the work was very successful, and by the middle of 1964 XYZ considered that it had developed a much improved and even novel instrument. In particular, XYZ had invented a novel thermocouple, which, in addition to measuring quite accurately the required higher range of temperatures, was also smaller than the LMN-ABC device. As well as using new materials for the thermocouple itself, XYZ also developed a new way of manufacture using electron beam welding. XYZ also simplified the associated electronics considerably, using up-to-date techniques, and as a result thought itself capable of producing an accurate pyrometer that would cost appreciably less than the one being sold by ABC.

As is their usual practice, the XYZ staff concerned with this development wrote a technical report, a copy of which went to the patent department with a covering note highlighting the advantages of the work and suggesting that patent protection be sought. Since, however, a fair amount of work in this field had been done, the patent department thought a quick search might, in the long run, save money if the design of the new pyrometer did not prove to be novel. To its surprise, the investigation showed that this development did seem to be an advance on the available art but that one aspect of the thermocouple design probably infringed one or perhaps two of the claims of the LMN original United Kingdom patent (on which, of course, ABC had a licence).

Meanwhile, the production directors of XYZ had seen the technical report on the new pyrometer and realized that the small size of the thermocouple, together with the simplified electronics, would give it a cheap, accurate instrument that could be used more widely than the more expensive ABC instrument. Control engineers thought that the new instrument might even be manufactured for around £50, which would enable them to use many more in the plant, something that had been uneconomic to do before, and thus control the operation of a plant more accurately.

In September 1964, the XYZ patent department applied for a United Kingdom patent on the improved thermocouple and sheath, acknowledging in the specification that it related in part to the earlier LMN United Kingdom patent, now well on in its life. In the usual manner, a notice giving the bare filing particulars of the patent application and a one paragraph résumé of its scope was circulated to the management, and by December 1964 it was decided to convene a meeting to decide what should be done about this invention.

At this meeting, representatives from the research and development laboratory, patent department, production control and divisional sales were present. The main points of their discussion are summarized below.

It was agreed that the development constituted an advance in thermocouple technology. The production representative thought that if the complete instrument could be manufactured cheaply, it could be used widely on process plant and give much better control than had so far been possible. Since the instrument also worked as well at lower temperatures, there might be a case for replacing and adding to several of their earlier instruments.

The patent agent advised that there was a good chance that a valid patent, at any rate in the United Kingdom, would ultimately be granted (although it was impossible to say so with certainty, since there might be unpublished patent applications being prosecuted that could affect the situation). More important, the design of the new thermocouple certainly would infringe at least one claim of the patent granted to LMN some years before. Apart from carrying out further research and development, XYZ would be at risk in using the new design of thermocouple without obtaining the permission of LMN or ABC, which appeared to be the licensee of LMN.

The meeting considered briefly whether the invention could be kept secret and used only by XYZ without the knowledge of others. However, the meeting thought it would be impossible, in the long run, to keep the invention secret, since XYZ was a large international company. It would also have to allow its patent application to lapse, with the risk that another organization might make the same invention and obtain patent protection on it for itself.

The representative of the production department also pointed out that XYZ was starting to purchase reagents from ABC, and LMN was a respected company in the United States known for its resolute pursuit of persons and organizations infringing their patents.

The meeting decided not to market the improved pyrometer. While it, unlike LMN, had adequate sales outlets, the market was small and not worth entering.

Finally, the representative of the patent department suggested that, as an opening gambit, a licence to manufacture and sell the XYZ pyrometer should be offered to LMN (not ABC, since ABC did not own the patent that XYZ believed it might infringe) on fairly generous terms in exchange for an assurance of freedom from suit under the LMN United Kingdom patent.

Although it was agreed that XYZ would ultimately want to use the pyrometer in plants in the United States and in the Federal Republic of Germany (where LMN also had corresponding patents), it was decided to deal with the situation in the United Kingdom first. The patent agent was therefore asked to inquire whether LMN would be interested in a licence on XYZ's new development, but the letter should not, of course, mention the possibility of XYZ's infringing LMN rights. He suggested, and the meeting agreed, that the letter not go off until a complete specification had been filed in the United Kingdom and the corresponding application made in the United States.

The United States application was filed in September, but XYZ, being a large company, did not get around to writing to LMN until November 1965.

How LMN and ABC viewed the XYZ proposal

LMN was not altogether surprised to receive the XYZ letter, since it had heard from an associate in the United Kingdom that XYZ was working on an improved pyrometer. LMN sent copies of the XYZ letter to ABC and also asked its patent attorney to study it. XYZ had enclosed only a descriptive extract from its United States specification (which excluded the claims), and thus it was difficult to see in detail the exact relationship between the XYZ development and that of LMN. Nevertheless, it was clear that the two designs had some common features, with the XYZ pyrometer seeming to be a distinct improvement on the one originally developed by LMN. LMN acknowledged the XYZ letter, said it might be interested, and requested a copy of the patent application as filed in the United States Patent Office. XYZ sent this to LMN at the end of 1965.

It happened that the two managing directors of ABC were due to visit LMN shortly, and LMN therefore resolved to discuss the question with them. LMN accordingly asked the ABC representatives to brief themselves on the XYZ proposals, finding out more information if they could from XYZ. The parties met in Los Angeles in January 1966. The subjects discussed are described below.

Novelty

The LMN patent attorney confirmed to the meeting that any pyrometer based on the XYZ design would almost certainly infringe one if not more of the claims of the original LMN patents in the Federal Republic of Germany, the United Kingdom and the United States, even though the claims granted in each of these countries were slightly different. As for the XYZ patent application, there seemed a good chance that it would result in a valid patent, though with somewhat narrow claims. Although the XYZ design showed considerable advances on the original LMN one, the permission of LMN would nevertheless be required for its use in those countries in which the LMN patents remained in force. LMN could therefore only restrain the XYZ activities, in practice, in the Federal Republic of Germany, United Kingdom and the United States, but as the main areas of operation of XYZ were in these countries, LMN felt that it was in a fairly strong position, at any rate for the next few years.

Business aspects

On the basis of the information given by XYZ, ABC realized that XYZ had taken a considerable step forward in the design of pyrometers. Not only had the temperature range been extended and accuracy improved, but the thermocouple itself could be made in a smaller and cheaper form. The only difficulty lay in its relationship to the original LMN patents, which were to lapse in the United Kingdom in some seven years. ABC decided it would very much like to manufacture the new pyrometer in addition to the one it manufactured under licence from LMN. The difficulty lay in having to obtain the permission of LMN to do that, at least for the next seven years unless it could be said that their current agreement would permit them to make the XYZ pyrometer as well. What would be awkward would be paying two royalties (the one of 10% to LMN under its agreement with LMN, and a second one to XYZ).

In its turn, LMN recognized that the XYZ thermocouple was an improvement on the LMN design, which it could immediately put to good use. The LMN attorney pointed out that XYZ also had a tough reputation in the matter of patents and if XYZ did not get a licence from LMN, XYZ would probably go ahead and use its design of pyrometer for its own purposes and challenge LMN to sue, a possibility that LMN did not relish. Even if LMN were able to prove infringement by the larger company, the royalty LMN would receive would be fairly small, since the selling price would be lower than with the LMN design of pyrometer. It therefore seemed sensible to give XYZ a licence on the understanding that LMN could use the new design itself free of charge.

The position vis-à-vis ABC seemed more difficult. ABC already had a licence to manufacture the pyrometers, which was defined as being based on the LMN design—a very general definition indeed. ABC might well argue that it could legally use the XYZ thermocouple design, merely paying a little more royalty to LMN in respect of the use of the XYZ component. (ABC had continued to purchase thermocouples and sheaths from LMN, deducting the money paid for these components from the price of their complete pyrometers for royalty purposes, as provided for in the LMN-ABC agreement.) Presumably, ABC would also have to make some payment to XYZ for the use of its design, but this might not matter very much as the XYZ design of instrument was much cheaper than the ABC design. Even with the LMN royalty being assessed on the pyrometer and the thermocouple, gross royalties received by LMN from ABC might fall substantially if ABC manufactured the XYZ instrument in its entirety.

The novelty of the XYZ development really lay in the new design of the thermocouple. LMN therefore resolved to try to persuade ABC to take only the thermocouple design from XYZ, reducing its royalty from 10% if some inducement seemed necessary. In this way the value of the pyrometers sold by ABC would be maintained and LMN royalties would not suffer too much.

The LMN-ABC proposal

LMN presented its ideas to ABC, which had also realized that manufacturing and selling a much cheaper instrument might increase the numbers sold, but total sales value, certainly in the first year or two, would be less than the value of the sales of the existing model, which would clearly be unsatisfactory. It therefore agreed with LMN's approach, proposing that LMN reduce its royalty substantially so that ABC did not pay more than 10% *in toto* to both LMN and XYZ. LMN agreed with this proposal in principle, and ABC decided to try to persuade LMN and XYZ to accept 5% each on the complete instrument and associated electronic units. Such an arrangement should appear reasonable to XYZ and not affect reagent sales, which ABC was just starting to make to XYZ.

The Second Agreement

ABC, LMN and XYZ met in London in March 1966 and after a relatively short time agreed as follows:

(a) The LMN-ABC agreement (First Agreement) would be terminated on 31 March 1966;

(b) A new tripartite agreement (Second Agreement) would come into force on 1 April 1966;

(c) Under the Second Agreement LMN would obtain free use of the XYZ design;

(d) XYZ would pay LMN a nominal royalty of £2 for each pyrometer it used;

(e) ABC would take a non-exclusive licence on the LMN and XYZ patent protection to manufacture and sell pyrometers in the United Kingdom and sell elsewhere. It would also have access to new information from both companies;

(f) ABC would pay a royalty of 5% to LMN until the original United Kingdom patent lapsed. It would also pay a royalty of 5% to XYZ until the LMN patents lapsed, after which the royalty would be increased to 10% for the remainder of the life of the XYZ patent;

(g) ABC agreed to continue selling an expensive version of its pyrometer (using the XYZ thermo-

couple) and not put the cheap XYZ instrument on the market;

(h) ABC would assess royalties on the complete instrument and associated electronic equipment.

The Second Agreement (see annex II) was signed on 15 March 1966 and came into effect on 1 April 1966. The arrangement proved eminently satisfactory to the three parties: whether the users of pyrometers were best served is another question.

Annex I

THE FIRST AGREEMENT–AGREEMENT RELATING TO THERMOCOUPLES

THIS LICENCE is made the twentieth day of January one thousand nine hundred and sixty *BETWEEN LMN CORPORATION* of 4098 Nineteenth Century Boulevard Los Angeles California United States of America (hereinafter called "the Licensor") *OF THE ONE PART* and ABC Limited of Walbrook Manchester United Kingdom *OF THE OTHER PART* hereinafter called "the Licensee").

WHEREAS the Licensee has requested from the Licensor a non-exclusive licence under all the patent applications hereinafter specified and the patents granted in respect thereof owned by the Licensor and the Licensor is willing to grant such licence; and

WHEREAS the Licensor has developed and is the owner of valuable information trade secrets and know-how relating to LMN Pyrometers (as hereinafter specified) and the Licensee wishes to obtain and the Licensor is willing to grant permission to use said information, trade secrets and know-how;

NOW THIS AGREEMENT witnesses and it is hereby agreed by and between the parties hereto as follows:

1. In this Agreement the following expressions shall have the following meanings:

"United States" means the United States of America, including its Territories and Possessions.

"United Kingdom" means the United Kingdom of Great Britain and Northern Ireland.

"The Applications" means the patent applications filed by the Licensor short particulars of which are set forth in the Schedule hereto.

"The Patents" means Letters Patent granted in respect of any of the Applications.

"The LMN Pyrometer" means a pyrometer for measuring temperature developed at the Licensor's Research and Development Laboratory at San Diego California United States and incorporating one or more of the inventions in respect of which the Applications have been filed.

"LMN Information" means drawings owned by the Licensor relating to the LMN Pyrometer together with information contained in test reports, operating instructions and the like owned by the Licensor relating to the LMN Pyrometer.

"The Pyrometers" means instruments for temperature measurement embodying or based upon any of the LMN Information and/or any of the Patents, including associated electronic equipment for the indicating and/or recording of temperatures.

"Net Invoice Price" means the ex works price contained in invoices issued by the Licensee to purchasers of the Pyrometers sold by the Licensee but deducting the costs of packing, freight and insurance where actually allowed and the costs of pyrometers and sheaths for pyrometers purchased from the Licensors.

2. This Agreement shall come into force on the first day of February one thousand nine hundred and sixty and shall be read and construed accordingly.

3. The Licensor hereby grants and the Licensee hereby takes any necessary non-exclusive Licence under the Patents to manufacture and sell the Pyrometers in the United Kingdom and to export the said Pyrometers from the United Kingdom.

4. The Licensee shall not assign mortgage charge or part with any of its rights, duties or obligations under this Agreement or grant sublicences without the previous consent of the Licensor in writing, which consent may be subject to conditions, including financial conditions.

5. Forthwith upon the date on which this Agreement comes into force the Licensor shall supply to the Licensee all the LMN Information, including one copy of every drawing and document containing such Information. The Licensee acknowledges that any of the LMN Information supplied or shown to its employees by the Licensor on or before said date shall be deemed to have been supplied under this Agreement.

6. The Licensor hereby grants permission to the Licensee to use the LMN Information for the production of the Pyrometers and parts thereof during the lifetime of this Agreement.

7. The use made by the Licensee of LMN Information shall be subject to the following conditions:

(a) The Licensee shall not communicate LMN Information to any third party;

(b) No claim of any sort shall lie against the Licensor arising from the use of LMN Information whether such Information be accurate or not;

(c) The Licensee shall use LMN Information for the sole purpose of manufacturing the Pyrometers for sale to third parties in accordance with the provisions of this Agreement;

(d) After the termination of this Agreement the Licensee shall not use LMN Information for any purpose whatsoever.

8. The Licensor shall supply to the Licensee on conditions to be agreed between them thermocouples and associated ceramic sheaths of similar design to those used by the Licensor in LMN Pyrometers. The price to be charged by the Licensor for said thermocouples and said sheaths shall be fair and reasonable and based on the Licensor's normal price computation for its standard products.

9. The Licensee shall during the period in which this Agreement remains in force pay to the Licensor a sum representing ten per centum (10%) of the aggregated Net Invoice Price of the Pyrometers and parts thereof sold by or on behalf of the Licensee.

10. The Licensee shall maintain true, clear and separate accounts of all Pyrometers sold by it or on its behalf and of all Royalties payable under clause 9 hereof and shall on or before the last day of March in each year during which this Agreement shall remain in force deliver to the Licensor a true account thereof (accompanied by a certificate from its auditors certifying that the said statements are correct) in respect of the preceding year up to the end of the last preceding February and shall at the same time pay to the Licensor the amount of such Royalties as may be shown to be due.

11. The Licensee shall permit the Licensor or its designated agent to inspect the said accounts and take copies of and extracts from the said accounts during normal business hours for the purpose of verifying the correctness of the royalty payments.

12. Subject to the provisions hereinafter stated this Agreement shall continue in force for fifteen years *PROVIDED THAT* the Licensor shall have the right at its option to terminate this Agreement at any time after the first day of February one thousand nine hundred and sixty-five after having given to the Licensee thirty months' notice in writing to that effect and *PROVIDED FURTHER THAT* the Licensor shall have the right at its option to terminate this Agreement forthwith by notice in writing to the Licensee upon the happening of any of the following events.

(a) If any Royalty hereunder (whether formally demanded or not) shall be in arrear for thirty days or more;

(b) If the Licensee having failed to perform or observe a covenant on its part to be performed or observed under this Agreement shall not have rectified its failure before the expiration of the period of fourteen days next following the date of the giving by the Licensor of a notice in writing specifying the said failure;

(c) If the Licensee shall have a Receiver appointed of the whole or any part of its assets or if an order shall be made or a resolution passed for winding up the Licensee unless the Licensor agrees that such order or resolution is part of a scheme of reconstruction of the Licensee.

13. Termination of this Agreement shall be without prejudice to any rights of either party against the other which may have accrued up to the date of such termination.

14. During the period of this Agreement the Licensee shall not oppose or assist others to oppose the grant of any of the Patents nor shall the Licensee dispute or assist others to dispute the validity of the said Patents or any of the claims thereof.

15. Neither the Licensor nor the Licensee shall be under any obligation to institute or defend any legal proceedings whether for infringement or otherwise in respect of any of the said Applications or any of the Patents.

16. Nothing in this Agreement shall be construed as a representation or warranty that any of the Patents are valid or that manufacture or sale hereunder is not an infringement of any valid and subsisting Letters Patent not owned by the Licensor.

17. The Licensee shall mark all the Pyrometers sold by it or on its behalf with a suitable indication that they are the subject matter of all or some of the Patents.

18. The Licensee shall use its best endeavours according to its resources to manufacture, promote and sell the Pyrometers for the maximum benefit of the parties hereto.

19. All disputes arising in connection with this Agreement shall be finally settled under the rules and procedures then obtaining at the American Arbitration Association by one or more arbitrators appointed in accordance with the rules.

20. This Agreement shall be considered a contract made in the State of California, United States, and shall be interpreted in accordance with the laws of the said State of California.

THE SCHEDULE

Country	*Patent application number*	*Patent number*	*Title*
United States of America			Improvements in or relating to Thermocouples
United Kingdom			Improvements in or relating to Thermocouples
Germany, Federal Republic of			Improvements in or relating to Thermocouples

IN WITNESS whereof the Licensor and the Licensee have caused this Agreement to be executed under hand by their duly authorized signatories upon the date first before written

Signed for and on behalf of
LMN CORPORATION

____

Witness ____________________

Signed for and on behalf of
ABC LIMITED

____

Witness ____________________

Annex II

THE SECOND AGREEMENT–AGREEMENT RELATING TO IMPROVED PYROMETERS

THIS AGREEMENT is made the fifteenth day of March one thousand nine hundred and sixty-six *BETWEEN LMN CORPORATION* of 4098 Nineteenth Century Boulevard Los Angeles California United States of America (hereinafter called "LMN") *OF THE FIRST PART*, XYZ Limited of Moorlands London United Kingdom (hereinafter called "XYZ") *OF THE SECOND PART;* and ABC Limited of Walbrook Manchester United Kingdom (hereinafter called "ABC") *OF THE THIRD PART.*

WHEREAS

(A) LMN is the registered proprietor of Letters Patent specified in Schedule 1 hereto;

(B) LMN has developed and is the owner of valuable information, trade secrets and know-how relating to LMN Pyrometers (as hereinafter specified) and ABC wishes to obtain and LMN is willing to grant permission to use said information, trade secrets and know-how;

(C) By an agreement made the twentieth day of January one thousand nine hundred and sixty between LMN *OF THE ONE PART* and ABC *OF THE OTHER PART* LMN granted ABC a licence to manufacture and sell the Pyrometers as defined in said Agreement upon terms specified therein;

(D) XYZ has filed Applications for Letters Patent in the countries and with the particulars specified in Schedule 2;

(E) XYZ has developed and is the owner of valuable information, trade secrets and know-how relating to XYZ Pyrometers (as hereinafter specified) and ABC wishes to obtain and XYZ is willing to grant permission to use said information, trade secrets and know-how;

(F) ABC has requested LMN and XYZ to grant it a licence to manufacture and sell the Improved Pyrometers (as hereinafter defined) on the terms and conditions herein appearing;

NOW THIS AGREEMENT witnesses and it is hereby agreed by and between the parties hereto as follows:

1. In this Agreement the following expressions shall have the following meanings:

"United States" means the United States of America, including its Territories and Possessions.

"United Kingdom" means the United Kingdom of Great Britain and Northern Ireland.

"LMN Patents" means Letters Patent specified in Schedule 1.

"The XYZ Applications" means Applications for Letters Patent filed by XYZ short particulars of which are specified in Schedule 2.

"The Patents" means the LMN Patents and Letters Patent granted in respect of any of the XYZ Applications.

"The First Agreement" means the agreement made the twentieth day of January one thousand nine hundred and sixty between LMN and ABC.

"The LMN Pyrometer" means any pyrometer for measuring temperature developed at LMN's Research and Development Laboratory at San Diego California United States, and incorporating one or more of the inventions the subjects of any of the LMN Patents.

"The XYZ Pyrometer" means any pyrometer for measuring temperature developed at XYZ's United Kingdom Research and Development Laboratory at Sheffield Yorkshire United Kingdom, and incorporating one or more of the inventions the subjects of any of the XYZ Applications.

"The Information" means drawings owned by LMN and XYZ relating to the LMN Pyrometer and the XYZ Pyrometer respectively together with information contained in test reports, operating instructions and the like owned by LMN and XYZ as the case may be.

"The Improved Pyrometers" means instruments for temperature measurement embodying or based upon any of the LMN Information and/or any of the XYZ Information and any of the Patents, including associated electronic equipment for the indicating and/or recording of temperatures.

"Net Invoice Price" means the ex works price contained in invoices issued by ABC to purchasers of the Improved Pyrometer sold by or on behalf of ABC but deducting the costs of packing, freight insurance, United Kingdom purchase tax and any trade discounts (other than cash discounts).

2. The First Agreement shall be deemed to be terminated with effect from the thirty-first day of March one thousand nine hundred and sixty-six.

3. This Agreement shall come into force on the first day of April one thousand nine hundred and sixty-six.

4. LMN and XYZ hereby grant and ABC hereby takes any necessary non-exclusive Licence under the Patents to manufacture and sell the Improved Pyrometers in the United Kigdom and to export the said Improved Pyrometers from the United Kingdom.

5. ABC shall not assign, mortgage, charge or part with any of its rights, duties or obligations under this Agreement or grant sublicences without the previous consent of LMN and XYZ in writing, which consent may be subject to conditions, including financial conditions.

6. Forthwith upon the date on which this Agreement comes into force LMN and XYZ shall supply to ABC all the Information, including one copy of every drawing and document containing such Information. ABC acknowledges that any Information relating to the XYZ Pyrometer supplied or shown to its employees by XYZ on or before said date shall be deemed to have been supplied under this Agreement.

7. LMN and XYZ hereby grant permission to ABC to use the Information for the production of the Improved Pyrometers and parts thereof during the lifetime of this Agreement.

8. The use made by ABC of the Information shall be subject to the following conditions:

(a) ABC shall not communicate the Information to any third party;

(b) No claim of any sort shall lie against LMN and XYZ arising from the use of the Information whether such Information be accurate or not;

(c) ABC shall use the Information for the sole purpose of manufacturing the Improved Pyrometers for sale to third parties in accordance with the provisions of this Agreement;

9. (1) Subject to subclause 2 of this clause ABC shall during the period in which this Agreement remains in force pay to LMN and ABC Royalties as specified hereunder. The said Royalties are as follows:

(a) In the period of this Agreement in which any of the LMN patents subsist ABC shall pay to each of LMN and XYZ a sum representing five per centum (5%) of the aggregated Net Invoice Price of the Improved Pyrometers and parts thereof sold by or on behalf of ABC;

(b) In the remaining period of this Agreement ABC shall pay to XYZ a sum representing ten per centum (10%) of the aggregated Net Invoice Price of the Improved Pyrometers and parts thereof sold by or on behalf of ABC.

(2) No sum equivalent to the whole or any part of the Royalty payable to LMN or XYZ shall be included in the price of any Improved Pyrometer which may be ordered by or on behalf of LMN.

10. ABC shall maintain true, clear and separate accounts of all the Improved Pyrometers sold by it or on its behalf and of all Royalties payable under clause 9 hereof and shall on or before the last day of April in each year during which this Agreement shall remain in force deliver to LMN and XYZ a true

account thereof (accompanied by certificate from its auditors certifying that the said statements are correct) in respect of the preceding year up to the end of the last preceding March and shall at the same time pay to LMN and XYZ the amount of such Royalties as may be shown to be due to LMN and XYZ respectively.

11. ABC shall permit LMN and or XYZ or its designated agent to inspect the said accounts and take copies of the extracts from the said accounts during normal business hours for the purpose of verifying the correctness of the royalty payments.

12. Subject to the provisions hereinafter stated this Agreement shall continue in force for fifteen years *PROVIDED THAT* LMN and XYZ shall have the right at their option to terminate this Agreement at any time after the first day of April one thousand nine hundred and seventy-one after having given to ABC thirty months' notice in writing to that effect and *PROVIDED FURTHER THAT* LMN and XYZ shall have the right at their option to terminate this Agreement forthwith by notice in writing to ABC upon the happening of any of the following events:

(a) If any Royalty hereunder (whether formally demanded or not) shall be in arrear for thirty days or more;

(b) If ABC having failed to perform or observe a covenant on its part to be performed or observed under this Agreement shall not have rectified its failure before the expiration of the period of fourteen days next following the date of the giving by LMN or XYZ of a notice in writing specifying the said failure;

(c) If ABC shall have a Receiver appointed of the whole or any part of its assets or if an order shall be made or a resolution passed for winding up ABC unless LMN and XYZ agree that such order or resolution is part of a scheme of reconstruction of ABC.

13. Termination of this Agreement shall be without prejudice to any rights of any party against the other which may have accrued up to the date of such termination.

14. During the period of this Agreement ABC shall not oppose or assist others to oppose the grant of any of the Patents nor shall ABC dispute or assist others to dispute the validity of any of the said Patents or any of the claims thereof.

15. Neither XYZ nor ABC shall be under any obligation to institute or defend any legal proceedings whether for infringement or otherwise in respect of any of the XYZ Applications and neither LMN nor XYZ nor ABC shall be under any obligation to institute or defend any legal proceedings whether for infringement or otherwise in respect of any of the Patents.

16. Nothing in this Agreement shall be construed as a representation or warranty that any of the Patents are valid or that manufacture or sale hereunder is not an infringement of any valid and subsisting Letters Patent not owned by LMN and or XYZ.

17. ABC shall mark all the Improved Pyrometers sold by it or on its behalf with a suitable indication that they are the subject matter of all or some of the Patents.

18. ABC shall use its best endeavours according to its resources to manufacture, promote and sell the Improved Pyrometers for the maximum benefit of the parties hereto.

19. Any disputes arising in connection with this Agreement between the parties shall be settled by Arbitration under the Rules of the International Chamber of Commerce.

20. The authorized address of any of the parties shall for the purpose of this Agreement be the last known address of such party. Any notice given in pursuance of this Agreement by any of the parties to another by registered ordinary letter or registered air mail letter addressed to the said authorized address shall be deemed to have been properly given ten days after posting.

21. This Agreement shall be considered a contract made in the United Kingdom and shall be interpreted in accordance with the laws of the United Kingdom.

SCHEDULE 1: LMN PATENTS

Country	*Patent application number*	*Patent number*	*Title*
United States of America			Improvements in or relating to Thermocouples
United Kingdom			Improvements in or relating to Thermocouples
Germany, Federal Republic of			Improvements in or relating to Thermocouples

SCHEDULE 2: XYZ PATENT APPLICATIONS

Country	*Patent application number*	*Title*
United Kingdom		Improvements in or relating to Pyrometers
United States of America		Improvements in or relating to Pyrometers
France		Improvements in or relating to Pyrometers
Germany, Federal Republic of		Improvements in or relating to Pyrometers
Italy		Improvements in or relating to Pyrometers
Japan		Improvements in or relating to pyrometers
Netherlands		Improvements in or relating to Pyrometers

IN WITNESS whereof LMN, XYZ and ABC have caused this Agreement to be executed under hand by their duly authorized signatories upon the date first before written

Signed for and on behalf of
LMN CORPORATION

____

Witness ____________________

Signed for and on behalf of
XYZ LIMITED

____

Witness ____________________

Signed for and on behalf of
ABC LIMITED

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Witness ____________________

II. SWEA-REMA: case-history of a licensing agreement

*Jan Monkiewicz**

The licensing agreement analysed in this paper was concluded in the summer of 1976. The licensor is the Swedish industrial group SWEA, with its headquarters in Stockholm; the licensee is the Union of Automation and Measuring Equipment (REMA), with its headquarters in Warsaw, Poland.

The subject of the licence is computerized numerical control (NC) system for machine tools, Tucon 400, property of SWEA. Tucon 400 is applicable to practically all types of machine tools. Apart from this basic system, the licensing agreement also covers the thyristor converter for feed drive and the thyristor converter for the main axis drive.

The only user of this system in Poland will be the factories of TOOLSMASH, the organization of the machine tool industry.

The licensor

Scope of activities

SWEA is a large industrial group in Sweden, consisting of 24 industrial firms and around 40 commercial firms and having some shares in other Swedish and some foreign firms. It is the eleventh largest heavy electrical firm in the world and has representatives in 50 countries. The scope of SWEA industrial activities is very broad. The areas it covers are described below.

Electric power

SWEA covers the entire field of electric power-generating equipment for hydro, fossil-fuelled and nuclear power stations, a.c. and d.c. transmission equipment for every voltage rating, distribution equipment and advanced supervisory and control systems for power stations, substations and complete power systems.

Industrial drives and industrial processes

Over many decades SWEA has acquired extensive know-how in the field of industrial drives and industrial processes. The company's role is not therefore limited to the delivery of motors, control gear and other electrical components. SWEA specialists have the expertise to design and adapt, in co-operation with industry and preferably from the planning stage, the control and monitoring functions so that the stipulated requirements concerning quality, costs, degree of automation etc. are met.

SWEA has developed drives for almost every branch of industry, including the necessary measuring devices, the transducers, that monitor the processes and inform the operating personnel, and the controls. Its industrial programme also includes ore handling systems, electric furnaces for steelworks and foundries and high-tonnage presses for metal forming.

Process control, computer technology

SWEA process-control systems have been developed on the basis of the company's know-how, resources and solid experience in building automatic and remote control equipment for industrial, power and transportation purposes.

Research and development policy

Within SWEA, development work has been decentralized. Manufacturing divisions and engineering departments, either on their own or jointly, carry out their own development projects. This procedure rationalizes decision-making and assures close contacts with the market. Interdepartment supervision of the projects eliminates duplication of work and ensures proper co-ordination of projects having similar objectives.

Studies required by the projects are handled as commissions by the SWEA Central Research and Development Department, which has the necessary personnel and laboratory resources to pursue

*Institute of Economic and Social Sciences, Warsaw Technical University, Poland.

advanced work in all areas of the company. In addition, this department is responsible for its own projects, both those lying outside the areas of responsibility of the product divisions and engineering departments and those of a long-term nature.

Special laboratories are established when necessary. One example is the high-voltage and high-power laboratories at Stockholm, which are important in the development of power transmission technology. Another is the high-pressure laboratory at Robertsfors, where new industrial production methods are developed.

At present, development work is being concentrated not only on individual components but also on complete systems. This makes it possible to build up equipment fulfilling different functional requirements from those of standardized units and modules.

This system concept characterizes the development also of equipment for industry, power plants etc. The objective is to achieve integrated control and drive systems, which ensure optimum utilization of resources and optimum production in the plant.

In recent years the company has been granted more patents than any other Swedish firm.

The licensee

REMA is the manufacturer of computerized automation and measuring systems, including industrial process control systems, data-processing equipment (computers and peripherals), and control and measuring equipment. REMA is thus concerned with the automation of various branches of economy in management, production, services and auxiliary processes.

The REMA Group includes 18 production units together with pilot plants, a foreign trade enterprise and a commercial enterprise supplying the domestic market, a design office, two scientific research institutes, eight research and development centres, specialized schools and training centres. The Group employs a total of 50,000 persons. In the plants associated within REMA new products are brought into the production programme every year that account for something like 30% of total production. The value of services and products sold in the period 1971-1975 and investment outlays tripled. Table 1 shows the growth of sales.

As a result of licence agreements concluded with the United States firm Honeywell, in 1975 REMA began to manufacture an electronic complex industrial automation system capable of being linked to an on-line computer.

Exports and imports of REMA are handled by its own foreign trade enterprise, TETRONED, which also handles imports and exports of numerous other organizational units not associated with REMA, mainly for industrial automation systems and control and measuring equipment.

TABLE 1. GROWTH OF REMA DOMESTIC SALES
(Billions of zlotys)

Item	*Year* 1970	1975	1976
Total sales (relative value)	4.2 (100)	15.1 (360)	18.5 (440)
Computer equipment	0.45	6.17	8.2
Process control	1.2	3.6	4.0
Measuring	1.6	3.4	3.8

In the period 1971-1975, REMA exports were valued at more than 1,300 million exchange zlotys. Table 2 shows the value and growth of exports in this period.

TABLE 2. GROWTH OF REMA EXPORTS

Year	*Value (millions of dollars)*	*Growth rate (%)*
1970	32	100
1975	130	410
1976	167	529

The most important buyer of REMA products is the Union of Soviet Socialist Republics, followed by the German Democratic Republic and Czechoslovakia. The most important Western European buyers are France, Germany, Federal Republic of, and the United Kingdom of Great Britain and Northern Ireland. Exports to Eastern European countries are the result of multilateral agreements concluded within the countries of the Council for Mutual Economic Assistance (CMEA) regarding the joint production of defined groups of products combined with specialization of the member countries.

An important part of the exports consists largely of entire automation systems for the complete industrial plants constructed, equipped and put into operation by Polish enterprises abroad.

Imports, handled by TETRONED, cover:

- Products manufactured by the CMEA member countries under long-term production specialization agreements
- Subassemblies and components for the manufacture of products made according to original designs or for licence-based production purposes
- Equipment for the automation of management techniques, industrial process control and measurements

The main import partners are Czechoslovakia, the German Democratic Republic, the Soviet Union, and among the Western European countries Austria, France, Germany, Federal Republic of, Italy and the United Kingdom.

The programme for a far-reaching computerization of industrial process and management systems that is being currently realized by REMA is expected to ensure a dynamic production growth that will be three times higher in the period 1976-1980 than that attained in the period 1971-1975.

Research and development and licensing policy

REMA scientific research and development are supported mainly by the Centre of Mathematical Machines, the Industrial Institute of Automation and the various research and development centres attached to individual industrial plants.

Two design offices are closely associated with the REMA Group: the INFORPROJEKT Information System Design Office concerned with, among other things, the design of computerized process control systems and computer centres and also with the development of software for computer control systems; and the Enterprise for the Design and Modernization of Automation concerned with all problems of developing the production potential of REMA plants. The Ministry of Machine Industry has entrusted the REMA Group with all work on the application of computerized management systems. Many computer control and management systems have been developed both for central organizational units of the Ministry of Machine Industry and for individual enterprises. An exceedingly fast rate of growth is to be expected in the line of computer equipment made by REMA plants closely linked with the computer industries of the CMEA member countries.

In this field Poland is fulfilling the tasks specified by the international agreement on the development of the unified CMEA digital computer system. After modernizing the production base, the production of the following computer equipment was started in the period 1971-1975:

- The RIAD 32 third-generation computer system for the Unified Digital Computer System of CMEA
- The ODRA-1305 and ODRA-1325 third-generation computer system with computing capacities many times higher than those featured by the second-generation machines
- A family of printers, including the up-to-date dot metrix printer type DZM-180 made under licence of LOGA, France
- Disc memories under licence from Control Data Company, United States of America
- Screen monitors licensed by STAN, Sweden

Much attention has been given to the development of software systems indispensable to industrial computer control systems. Problems of software development are the chief activity of two specialized offices: the Office for the General Supply of Medium-Sized Computer Systems and the Office for the General Supply of Minicomputer Systems. Both these general suppliers ensure the complete range of services indispensable for the application of computer and minicomputer systems.

REMA carries on an active licence policy, complementing through licensing agreements the output of its own research and development. By now REMA has acquired 36 licences, 15 of which were imported before 1970 and 21 after 1970. Cumulative payments resulting from these arrangements have reached about $20 million.

REMA acquired its first licence in 1958 from a firm in the Federal Republic of Germany. Other important licences acquired include:

- Computer printing device (United Kingdom)
- Small disc memories (United States)
- Electronic systems of continuous regulation (United States)
- Time transmitter for energy protection (Sweden)
- Computer terminals (France)

The first licence from SWEA was acquired in 1971, the second, in 1973.

Licence-based production of REMA accounts for about 19% of the total value of its production and licence-based export for 42% of the total value of its exports.

Position of licensor and licensee before licensing agreement

Licensor

SWEA is one of many firms manufacturing computerized NC systems for machine tools. It sells its NC system both at home and abroad, foreign sales being very important. Export to Eastern European countries before the licensing agreement was, however, very small. Table 3 shows the markets for SWEA products.

During this period sales to Eastern Europe were negligible. The company, however, is now turning its attention to CMEA countries; it has set up commercial and technical offices in the German Democratic Republic, Poland, Romania and the USSR.

Licensee

Before purchasing the licence, REMA had not produced a computerized NC system for machine tools, but, as already mentioned, the Centre of Mathematical Machines of REMA and the Central

TABLE 3. SWEA SALES BY AREA, 1972-1976

(Millions of dollars)

Area	1972	1973	1974	1975	1976
Western Europe (excluding Sweden)	366	440	525	564	569
Eastern Europe	31	36	62	53	58
North America	61	58	49	109	130
Latin America	38	45	42	68	92
Australia, New Zealand	22	26	27	38	32
Asia	24	39	50	66	127
Africa	16	17	20	53	55
	558	661	775	951	1 063
Sweden	644	613	904	957	976
Total	1 202	1 274	1 679	1 908	2 039

Machine Tool Design Office of TOOLSMASH had designed their own computerized system for control of machining centres. However, substantial outlays and time for technological development were still required.

Two considerations impelled REMA to undertake production of a computerized NC system of machine tools: the interest of Poland in maintaining its position as the leading manufacturer of machine tools in Eastern Europe and growing internal demand.

Selection of product

The production and export of machine tools are heavily concentrated. It is estimated that six major industrialized countries–France, Germany, Federal Republic of, Italy, Japan, the United Kingdom and the United States–account for 30% of the total supply and are also the major world exporters of machine tools.

NC machine tools are multifunctional machines. Production and export of these machine tools are growing rapidly. The value of exports of NC machine tools from the United Kingdom, for example, grew from $6 million in 1968 to around $16 million in 1970. The value of exports of NC machine tools from the Federal Republic of Germany grew from $18 million in 1969 to $23 million in 1970. In the same year Japan exported 46 units of NC machine tools and France, 60.

NC machine tools became of strong interest to the Polish machine tool industry and were incorporated into the plan for acquiring licences from abroad in 1976.

Selection of licensor

PEMA carried out a broad survey of potential licensors of the required technology. It carried on exploratory talks with 12 leading world firms manufacturing NC systems in six countries:

Germany, Federal Republic of
- Siemens

Japan
- Fujitsu-Fanuc
- Okuma

Norway
- Kongsberg

Sweden
- SWEA

United Kingdom
- Cincinnati
- Herbert
- Microcomputer Systems
- Plessey

United States of America
- Bendix
- General Automation
- General Electric

Finally, after introductory proceedings, licensing offers for computerized NC systems were made by only three firms–SWEA, Okuma and Siemens.

After a detailed analysis of the offers made, SWEA and Siemens were selected for final talks. The final negotiations and a detailed investigation of the technological features and design of NC systems offered and the commercial terms of the offers led to the decision in favour of SWEA. An additional factor influencing the choice was the long-term relationship between SWEA and Poland, for the firm has had a technical and commercial office in Poland since 1925.

Commercial, technical and financial considerations

From the technical point of view the following factors worked in favour of SWEA as against Siemens:

(a) The up-to-date design of the Tucon 400 system was estimated to keep abreast of technological progress in this domain for another five to seven years. The Sinumerik 520 CE and 550 CE of Siemens would be kept in the production programme for only two or three years;

(b) The Tucon 400 system covered the whole range of machine tools manufactured in Poland, whereas Siemens Sinumerik covered only some;

(c) The number and type of controlled axes made possible the use of the Tucon 400 system in modern machining centres with a movable stand, automatic recharge of objects fastened to the panel etc., which conformed with technological trends in this area;

(d) The Tucon 400 had some advantages:

(i) It had two times higher accuracy of displace;

(ii) Its program feeding was more accurate owing to its three-step selection;

(iii) Machine parts could be described both in centimetres and inches (the Siemens systems only in centimetres);

(e) The optioisolators applied at the entry of Tucon 400 were more reliable and more resistant to disturbances than the filters used in the Siemens systems;

(f) The production technology of Tucon 400 could be more easily adapted to the technology applied in REMA plants than the production technology of Sinumerik.

In addition, the resolver, used as a converter for tapping, was cheaper by about $1,000 per piece than the rotary-impulse converter used by Siemens.

From the commercial and financial standpoint the SWEA offer was superior to that of Siemens in the following respects:

(a) The SWEA offer ensured the joint development of the system whereas Siemens was to start producing a new system in collaboration with a Japanese firm;

(b) The total contract price, including documentation, know-how, training, consulting, machinery and equipment and 150 items of the system in various stages of assembling was 20% lower than that asked by Siemens;

(c) SWEA guaranteed in the agreement a certain value of the buy-back arrangement, whereas Siemens wanted to define the value well before signing the agreement.

Negotiation process

The negotiation of the agreement, because of both the technical complexity of the subject and the commercial aspects involved, proved to be difficult; and the licence in question was, in fact, part of a much wider co-operation agreement, which meant that many commercial variables were strongly interrelated and dependent on each other and that the price of the licence was not particularly important.

The two crucial points of the negotiations concerned export rights and the scope of the compensation agreement related to the licensing agreement in question.

At the beginning of the negotiations SWEA offered REMA non-exclusive export rights limited to the CMEA countries- Bulgaria, Cuba, German Democratic Republic, Hungary, Mongolia, Romania and the USSR. REMA in turn demanded exclusive export rights for the CMEA countries and non-exclusive rights for the rest of the world, excluding Scandinavia. After long discussions REMA was granted non-exclusive export rights for the CMEA countries and non-exclusive export rights for the rest of the world when the licensing product was supplied with machine tools manufactured in Poland. Export was also permitted when the licensing product was a part of foreign-made machine tools exported by the Polish foreign trade enterprise in a turnkey project.

The compensation trading agreement supplementing the licensing agreement was a condition *sine qua non* of the licensing agreement. REMA originally asked SWEA to commit itself to purchase a defined value of electronic components manufactured by REMA, payment to be made by an annual lump sum. SWEA managed, however, to introduce a clause according to which the payment might be renegotiated after three years of the period of the contract.

Summary

The case described is characteristic for investment goods. The prospective producer of the computerized NC system had only one customer–TOOLSMASH, which in fact had a decisive voice in determining the type of technology to be acquired. All during the negotiations, TOOLSMASH was in constant contact with REMA, defining its needs and priorities.

The prospective licensor devoted most of its attention to a technical analysis of the offers and much less to their commercial and financial aspects. This emphasis is typical where development is planned–investment goods are in short supply.

III. ROVETA-ARTUR: case-history of a licensing agreement

*Jan Monkiewicz**

The licensing agreement described in this paper was concluded in November 1975. The licensor was ARTUR AG, an equipment manufacturing firm in the Federal Republic of Germany, and the licensee, ROVETA, in Poland. The licensing agreement provided the Polish licensee with the property rights, know-how and technical documentation required for the production of some models of compact automatic washing machines of ARTUR. The licensing agreement covered in particular the following models of compact automatic washing machines of ARTUR:

Berta A	500 rev/min, 65 cm high
Berta B	500 rev/min, 85 cm high
Susan A	800 rev/min, 65 cm high
Susan B	800 rev/min, 85 cm high
Susan C	1,000 rev/min, 65 cm high
Kurt A	800 rev/min, 65 cm high
Kurt B	800 rev/min, 85 cm high

The data given below are, in general, real, although in some cases, because the contracting parties requested it, they have been somewhat changed. These changes, however, in no way affect the substance of the case-history.

The licensor

ARTUR, with its headquarters in Solingen, Federal Republic of Germany, is a small production firm specializing in the manufacture of compact automatic washing machines and household dishwashers. Its main plant, in Solingen, employs over 1,000 persons and has at its disposal six assembly lines for manufacturing compact automatic washing machines. Its average annual output is around 250,000 units.

Parallel to the production of compact automatic washing machines, the product of its own research and development, ARTUR also manufactures household dishwashers under licence from a firm in the United States of America.

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The market position of ARTUR is a special one in that it does not sell under its own name on the market in the Federal Republic of Germany. Products manufactured by ARTUR are sold by Siemens, Allgemeine Elektrizität Gesellschaft (AEG), Constructa and Electrolux, naturally under the names of the sellers. The products manufactured by ARTUR are also sold in large department stores. ARTUR has a small research and development department employing several dozen persons.

The licensee

Structure and turnover

ROVETA, located at Warsaw, has numerous affiliated production works, experimental plants, research and development centres and design-engineering offices. It employs a total of about 70,000 workers.

The plants associated with ROVETA employ almost all the known industrial production processes, such as casting of iron and non-ferrous metals, pressure casting of aluminium and its alloys, precision machining and cold or hot plastic working of metals, processing of plastics, chemical heat treatment, lacquering and electroplating. Each plant has its own research laboratory and experimental workshop.

The range of products made by the ROVETA plants is extremely wide. However, for some time ROVETA has been successfully specializing in the production of durable and general consumer goods, including mechanized household appliances and tourist-camping equipment, and office equipment and machines.

ROVETA's production, which has been increasing annually, is not only extremely diversified but also technically advanced. Owing to the introduction of up-to-date equipment and constant improvement of process methods, a steadily growing number of their products bear the "1" and "Q" quality marks, which are awarded by the Central Product Quality Office of the Ministry of Home Trade and Services in Poland to products of the highest technical standards and matching international standards. Table 1 shows domestic sales growth.

TABLE 1. GROWTH OF ROVETA DOMESTIC SALES

Year	*Value (billions of zlotys)*	*Growth rate (%)*
1970	10.9	100
1975	21.3	195
1976	24.9	228

The production of new products in 1976 doubled as compared with production in 1971. Such a high production growth rate and the constant introduction of new products on the market has been made possible by active participation in international co-operation. Two main types of such co-operation can be enumerated:

Economic links, including co-operation agreements and bilateral or multilateral trade agreements

Scientific-technical co-operation, consisting of training, consultations, exchange of technical documents and information, preparation of technical elaborations and joint research

Table 2 shows the dramatic increase of ROVETA exports.

TABLE 2. GROWTH OF ROVETA EXPORTS

Year	*Value (millions of dollars)*	*Growth rate (%)*
1970	64.6	100
1975	97.4	151
1976	117.2	181

Investment outlays of ROVETA for the development of mechanized household appliances in the period 1976-1980 was expected to be six times higher than in the period 1971-1975. The growth of more important groups of general-use products is shown in table 3.

TABLE 3. GROWTH OF PRODUCTION, 1971-1980
(Thousands of units)

Product	*1971-1975*	*1976-1980*
Refrigerators	2 300	4 000
Vacuum cleaners and floor polishers	3 300	5 400
Mechanized kitchen appliances	2 550	6 550
Gas and electric stoves	2 970	4 800
Fans and ventilation equipment	1 970	5 000
Sewing machines	1 400	1 900
Bicycles and mopeds	4 900	8 400
Irons	7 200	11 400
Automatic washing machines	146	1 180

Research and licensing policy

ROVETA has at its disposal considerable research and development potential, the main aim of which is to improve products under current production and to develop new technologies that might be useful for ROVETA plants. However, its research capacity cannot meet all its requirements for new technology. Thus ROVETA is pursuing the policy of concentrating research and development in selected areas of production and acquiring new technology for other areas from abroad. The manufacture of automatic washing machines is based solely on imported technology.

ROVETA actively engages in licence purchasing, trying at the same time to link licensing agreements with industrial co-operation agreements. The goal of ROVETA is to see that each licensing agreement it enters into contains a counter-purchasing clause, according to which the licensor will be bound to buy back a certain part of the production manufactured under its licence, either final products or components. This policy makes it possible for ROVETA to realize some advantages of scale and to obtain some hard currency. Additionally, it puts ROVETA step by step into the world-wide network of producers and makes it easier for ROVETA to adapt to the sophisticated Western markets.

ROVETA has considerable experience in licence purchasing. It acquired its first licence in 1961. It covered the rights to production and sale of cooling aggregates and was obtained from a firm in the Federal Republic of Germany. By 1970, ROVETA had acquired six licences, with cumulative royalties of $400,000. Within the period 1971-1975, ROVETA acquired five licences from Western firms with a value of several million dollars, as follows:

Calculating machines, adding machines with recording, from CALCULATOR, Sweden

A series of types of automatic washing machines from ARTUR, Federal Republic of Germany

Automatic dish-washing machines from DISHWASHER, Italy

Typewriters from WRITER, Sweden

Domestic sewing machines from CITIZEN, United States

Licence-based production accounts for about 5% of the total ROVETA output; licence-based exports account for 7% of its total exports.

Position of licensor and licensee before licensing agreement

Licensor

ARTUR's share in the market for compact automatic washing machines in the Federal Republic of Germany is small. Production facilities of ARTUR are limited to the Federal Republic of Germany so that it can expand its production either by simple exporting or licensing. Its exports are insignificant. ARTUR products appearing on national and international markets face sharp competition from such well-known producers as Siemens, AEG and Miele.

The range of compact automatic washing machines offered by ARTUR for licensing has been manufactured by this firm since 1973. Under the pressure of sharp competition, coupled with its narrow specialization and small production capacity, ARTUR is keen on licensing.

ARTUR compact automatic washing machines have not been exported to countries in Eastern Europe, whereas some of its competitors have already entered these markets. Some years earlier the Soviet Union purchased the licence for compact automatic washing machines from the United States firm BIZON and Hungary purchased a similar one from AEG Telefunken.

Licensee

ROVETA has a monopoly of the Polish market for several consumer durables, washing machines among others. Up to the conclusion of the licensing agreement with ARTUR, ROVETA had been manufacturing mainly hand-operated electric washing machines. There was still high demand for them owing to their low price and reasonably good performance. These electric washing machines were based upon technology coming from ROVETA research and development facilities. Parallel to that production, ROVETA had been manufacturing household automatic washing machines under licence from ZORJA, Yugoslavia. Production output of the latter was around 200,000 units per year.

ROVETA production of washing machines is primarily for the domestic market; only a minor part is exported to some Eastern European countries. These markets, however, are also supplied by producers from the German Democratic Republic, Hungary and Yugoslavia and recently also from the Soviet Union. The technical level of ROVETA production of washing machines, both as regards the product design as well as technological procedures applied, was rather low before it entered into the licensing agreement and lagged considerably behind the world level in this respect. The same was true as regards ROVETA research and development in this area. It was estimated that the elaboration of a project for a new product comparable with the performance indicators of those offered under licensing agreements would have required at least several years of research and development. It would have also required substantial financial means. The situation was additionally complicated in that several basic elements of construction such as automatic control, system of vibration damping and driving elements were protected by patents of several foreign manufacturers.

Selection of product

The washing machines manufactured by ROVETA satisfied Polish consumers as long as consumers were not especially fussy. However, as the demand for washing machines increased, the demand for a more sophisticated automatic washing machine also increased. The high proportion of women employed in Poland means that any technical innovation that can save time in the household is eagerly acquired, even if the price is high.

The production of automatic washing machines begun in 1969 under licence from ZORJA, Yugoslavia, filled a real need. Effective demand significantly exceeded ROVETA expectations and resulted in a considerable increase of production, thus leading to adjustments in the targets initially planned.

The automatic washing machines made under the ZORJA licence are large units, and they do not meet the requirements of many potential customers, because flats currently built in Poland are small, and in particular the kitchens and bathrooms, the traditional places for washing machines, are small—6-8 m^2 and 3-5 m^2, respectively. Thus demand could be satisfied only with compact automatic washing machines, a recent development of technology in this area.

The market for this product increased dramatically during the period 1971-1975 owing to the vast housing programme launched by the Polish Government and to the tremendous inflow of young people to production areas.

In deciding to begin production of compact automatic washing machines, ROVETA opted for an up-to-date technology reflecting current trends in highly industrialized countries. It sought technological novelty in design, production methods and functions.

Selection of licensor

ROVETA took the preliminary decision to launch licence-based production of compact automatic washing machines in 1973. Subsequently the Ministry of Foreign Trade instructed the Polish commercial attachés abroad to identify prospective licensors and what inducement they needed for making formal contract offers to UNIVERSAM, the foreign trade enterprise responsible for arranging all foreign economic contacts for ROVETA. The whole matter was, however, unclear, and there was no ground for taking more formal steps in this respect.

Formal steps to enter into a licensing agreement, according to Polish law, can be taken only when licence purchasing is incorporated into the plan for licensing imports. However, as the plan for licensing imports covers only one year, five-year plans in this area are more of a statement of goals than a real plan. Market research must be started well in advance before incorporating a given licence into the plan for licensing imports. Otherwise the prospective licensee would have to complete all the formalities relating to the purchase of a licence within the planned period or to repeat his request for currency, investment funds etc. during the next planning period.

In 1975, ROVETA decided to incorporate a licence for compact automatic washing machines into the plan for licensing imports for 1976. It then started intensive market research to identify prospective licensors, and it decided to send representatives to the international fair for consumer durables, Domotechnica, that takes place each year in March in Cologne. The ROVETA representatives who attended the fair in 1975 held many preliminary talks with representatives of Siemens, AEG Telefunken, Miele, Thomson Brandt and Zanussi. As a result of these talks, two firms were eliminated. Neither was interested in the type of contract that ROVETA representatives were seeking.

Other firms expressed interest in continuing further negotiations. Among the products of these displayed at the fair, ROVETA representatives paid particular attention to those of ARTUR, which name was not recorded in ROVETA files. During introductory talks they learned that ARTUR, which presented its products during the fair under its own name, normally sold its products under the names of well-known producers of household appliances. They learned, for instance, that in the Siemens catalogue compact washing machines manufactured by ARTUR were listed under the names WAMAT 391 and WAMAT 370.

The ROVETA representatives were impressed by the ARTUR product mix and the attitude of its representatives. In October 1975, during the exhibition "Poland 1975", organized in Essen, the negotiations with ARTUR continued. This time they were carried on by the representatives of UNIVERSAM.

As a result of the talks, in November 1975 ARTUR sent UNIVERSAM information regarding its industrial activity, including technical data for its products, and expressed in writing its interest in establishing co-operation with Poland in the manufacture of compact automatic washing machines. In the meantime, in October 1975, UNIVERSAM had received licensing offers from firms in the Federal Republic of Germany, Finland and Italy. At the same time a licence to import compact automatic washing machines had already been incorporated in the plan for 1976, thus laying the formal basis for further action.

In January 1976, a delegation of ARTUR representatives arrived in Warsaw to continue the introductory negotiations begun in the Federal Republic of Germany. In the course of talks with ROVETA top management, it was agreed that in the near future ARTUR would send ROVETA a few sample units of its compact automatic washing machines for testing by ROVETA experts. The 10 sample units arrived in Warsaw by air in February 1976 and were immediately subjected to various technical tests.

ARTUR then suggested having another meeting with representatives of ROVETA at the international fair at Cologne, Domotechnica, in March 1976.

Consequently, a ROVETA delegation visited ARTUR in early March 1976. It became acquainted with the details of ARTUR manufacture of compact automatic washing machines and stated more precisely ROVETA requirements relating to the prospective licensing agreement. The outcome of the talks was that both parties agreed upon the following points:

(a) ROVETA was interested in a licensing arrangement with ARTUR with respect to compact automatic washing machines;

(b) ARTUR promised to deliver to UNIVERSAM a draft of the licensing agreement with ROVETA in which the following items were to be included:

- (i) Commitment of ARTUR to commercial and technical co-operation with ROVETA for at least 5 years, starting from the date of the conclusion of the agreement;
- (ii) Commitment of ARTUR to deliver the necessary technical documentation;
- (iii) Commitment of ARTUR to clarify the patent situation of the patented elements of design;
- (iv) Commitment of ARTUR to train a certain number of Polish specialists in the Federal Republic of Germany and to send ARTUR experts to assist ROVETA in producing in Poland;
- (v) Specification of export rights of ROVETA;
- (vi) Price of licence and terms of payment;
- (vii) Commitment of ARTUR to purchase a certain quantity of compact automatic washing machines produced under its licence in ROVETA plants (buy-back commitment).

During the visit to the Federal Republic of Germany, the ROVETA delegation carried out some exploratory talks with Siemens and AEG Telefunken. Both firms were ready to sell a licence for the models of products that had already been withdrawn from their production programmes.

After the ROVETA delegation returned to Poland, the firm got in touch with UNIVERSAM to make arrangements to start up the import procedure stipulated by Polish law.

In May 1976, another delegation of ARTUR representatives arrived in Warsaw to continue the talks on the conditions of the licensing offer. At this time the basic clauses of the prospective agreement were agreed upon.

In the meantime, as a result of the efforts of UNIVERSAM on behalf of ROVETA, a firm in the Federal Republic of Germany sent a preliminary licensing offer, and asked at the same time for some more details regarding ROVETA requirements in this respect. In June 1976 another firm in the Federal Republic of Germany informed ROVETA that it could not begin licensing negotiations with ROVETA at the moment, but might return to the subject in a year.

In July 1976, after considering the offers for licensing agreements it had received, ROVETA decided to sign a licensing agreement with ARTUR. The team that negotiated the terms consisted of representatives of the ROVETA central management, representatives of prospective manufacturers of compact automatic washing machines and representatives of UNIVERSAM.

In October 1976, ROVETA signed a "realization agreement" with UNIVERSAM, after which it was to initiate final negotiations with the prospective licensor.

Negotiation process

Negotiations with ARTUR went smoothly, since most of the important clauses had been agreed upon during the prenegotiation talks. The crucial and most difficult matters to be settled were export rights, the price and terms of payment and the scope of the buy-back commitment by ARTUR.

The initial offer of ARTUR was to grant ROVETA non-exclusive export rights for the other Eastern European countries of the Council for Mutual Economic Assistance (CMEA)–Bulgaria, Czechoslovakia, German Democratic Republic, Hungary, Romania and the Soviet Union. The ROVETA negotiators demanded, however, exclusive export rights for the CMEA countries as well as non-exclusive rights for Western markets, excluding the Federal Republic of Germany and Scandinavia (Denmark, Finland, Norway and Sweden). After several discussions and a reduction in the price of the licence, it was agreed to grant ROVETA only exclusive export rights for the CMEA area with no access to outside markets.

ARTUR demanded a lump-sum payment to be made every year during the period of the agreement. It asked additionally for an initial payment equal to one third of the total value of the agreement. Finally, the terms offered by ARTUR were accepted, but the initial payment was reduced to one fifth of the total value of the agreement.

ROVETA considered the buy-back commitment a particularly important clause of the agreement. It initially asked ARTUR to commit itself to purchase annually 5,000 units of washing machines from current production. ARTUR, for its part, wished to cut down this demand and suggested defining the buy-back commitment in terms of the duration of the agreement instead of on a yearly basis. A compromise was reached in the end. The buy-back commitment was reduced to 4,000 units per year and calculated over a two-year period.

Commercial, technical and financial considerations

According to the analysis of ROVETA experts, the products offered under licence by ARTUR are technically better than those offered by its competitors with respect to the design and functioning of the products.

The compact automatic washing machines offered by ARTUR under the licensing agreement are particularly advantageous vis-à-vis competing products in the following respects:

(a) Elements and components are 80% interchangeable in spite of diversified choice of product;

(b) Their size makes possible their use in small apartments;

(c) They provide a full range of washing programmes and capacities;

(d) They are very stable and make little noise when operating because of optimal choice of their specific weight;

(e) Without changing the design of most of the elements and components, three different spinning speeds can be obtained–500, 800 and 1,000 rev/min–and drying can also be included;

(f) They have all the electric and functional safety features required by the most recent regulations;

(g) The share of elements of the original design in total value is about 75%.

Launching the licence-based production will require high investment outlays, of which two thirds is to be obtained from Western countries. During the first phase of production parts and assemblies, valued at 35% of the total value of production, will have to be imported. Imports will, however, soon be replaced by local substitutes. These imports will to some extent be paid for through the buy-back arrangement stipulated in the agreement.

Licensing payments are defined as lump sum and are to be made in equal parts during the period of the agreement.

Export of the licence-based production is limited to the European members of CMEA. The general coefficient to determine whether it is economic to acquire the licence is given by the following simplified formula:

$$E = \frac{P - K}{I(r + s) + Br}$$

The condition for effectiveness is $E_{min} \geqslant 1$, where:

- E = coefficient of economic effectiveness
- P = planned value of annual production
- K = planned value of operating cost of production P less depreciation, credit interest plus tax on wages equal to 20% of the stipulated wage fund
- r = rate of discount of 8% annually
- s = average rate of depreciation
- I = value of investment outlays
- B = annual outlays for circulating capital

The value of investment outlays $I = A \cdot z$, where A is the value of nominal investment outlays and z is the coefficient of lock-up, given by the formula $z = 1 + \frac{b \cdot r}{2}$, where b is the period of realization of investment venture in years. The values of z for values of b from 1 to 7 are given below:

b	1	2	3	4	5	6	7
z	1.04	1.08	1.12	1.16	1.20	1.24	1.28

In Poland, $E_{min} = 3.37$.

Summary

The entire acquisition process from the exploratory contacts to the conclusion of the licensing agreement lasted nearly two years. During this period representatives of the licensee went abroad several times to explore the market and to carry on technical and commercial negotiations, and representatives of the licensor came frequently to Poland. Thus, the acquisition process was rather long and time-consuming, even though the geographical proximity of licensor and licensee cut down the time—and the costs—of communication.

For the Polish negotiators, the main determining factors in purchasing the licence were technical and commercial factors, particularly those concerning foreign trade. The licensing payments themselves were of secondary importance.

IV. Hindustan Photo Films, Ootacamund: a case-study of acquisition and assimilation of technology

*K. Balakrishnan**

Acquisition of technology

Soon after India became independent (in 1947) the Government realized that the country would need to secure a regular supply of various types of film—cine film for the Indian motion picture industry, X-ray film for health services and film for professional and amateur photographers. At that time all photographic materials had to be imported. To make the country self-reliant in this field, the Government encouraged private enterprise to manufacture sensitized photographic materials with foreign collaboration, but its efforts failed. After a Film Enquiry Committee set up by the Government assessed the requirements of the motion picture industry, in 1951, the Government decided to set up a public-sector enterprise to manufacture photographic materials.

At that time the Government faced a situation that many developing countries trying to set up factories to manufacture new products face—determining who will search for the technology, negotiate with the potential collaborators and promote the project. No ministry of the Government had the technical competence to search for the technology for the new enterprise. Nor was there any private enterprise or research laboratory that could perform this function. Finally, the National Industrial Development Corporation (NIDC) in the public sector was assigned the job, probably because it had some experience in negotiating with foreign parties. Although a foreign consulting firm with more expertise in the field of photographic materials might have been asked to search for the foreign collaborator, the feeling was that Indian consultants should be entrusted with the responsibility.

In 1951, the Government contacted several internationally known manufacturers of photographic goods in Western Europe, the German Democratic Republic, Japan and the United States of America with a view to finding a foreign collaborator for the public-sector enterprise it intended to set up. Negotiations with one company in the German Democratic Republic proceeded quite far, but finally, in 1956, collapsed. During the next four years the Government held discussions with other manufacturers. Suitable offers were received from two firms, Adox (Federal Republic of Germany) and Bauchet (France); NIDC conducted detailed negotiations with both these firms. Technologically, there was little to choose from between Adox and Bauchet; therefore, the financial terms were decisive. Adox demanded a 5% royalty for 25 years as against a lump-sum payment of $6.1 million (including the cost of imported machinery and equipment) asked by Bauchet. On 21 November 1959, the Government decided to accept the offer from Bauchet.

To be sure, if a firm with the reputation of Kodak had made an offer, even with stiffer terms, the Government might have preferred that firm to Bauchet. However, the firms with bigger names did not seem to consider it worth their while to negotiate with the Government to set up a plant in India. Some of the larger firms that did show tentative interest either did not wish to collaborate with the Government, wanting instead to set up a wholly owned subsidiary, or wished to market the products under their own brand names using the Indian factory merely as a unit for converting their jumbo rolls into packaged products.

On 25 April 1960, the Government formally entered into a technical collaboration agreement with Bauchet. It was signed by the president of Bauchet and the Indian ambassador to France. It came into effect the following October, after a sample of the cine positive film, one of the products to be supplied by the collaborator, had been tested and accepted by the Government.

The agreement provided that Bauchet was to be paid $6,081,632 (Rs 29.3 million) for furnishing a detailed project report (DPR) and machinery and equipment, supervising the erection of the factory

*Indian Institute of Management, Ahmedabad, India.

and providing consulting services for starting production. In addition, the collaborator was also to be paid, in dollars, 1.5% of the net value of sales for the third, fourth and fifth years after production had begun, for rendering after-sales services.

On devaluation of the Indian rupee, the lump-sum payment increased from Rs 29.3 million to Rs 37.4 million. The total payment turned out to be as follows (millions of rupees):

Lump-sum payment	37.40
Interest on deferred payment	8.22
After-sales service payments (until 1972)	1.70
Total	47.32

The agreement is summarized in annex I.

Establishment of HPF

To implement the agreement, a new enterprise was incorporated as the Hindustan Photo Films Manufacturing Company Ltd. (HPF) on 30 November 1960. It was set up as a wholly owned government company to attain "self-sufficiency in the manufacture of photographic products ... to meet Indian requirements in education, health and entertainment". The collaboration agreement was formally assigned to HPF in April 1961.

The new HPF plant was erected at Ootacamund (Ooty), a hill station in South India at an altitude of 8,000 feet. In 1955/56, when it appeared that a film company in the German Democratic Republic would be the foreign collaborator, experts of this company carried out a survey of eight possible sites for the factory. They were looking for a site with *(a)* favourable atmospheric conditions; *(b)* availability of good water; *(c)* suitable land; and *(d)* adequate labour. They evolved a scale of 100 points distributed over the four factors and subfactors, and, on the basis of this scale, Ooty was chosen.

The importance attached to plant location can be seen from the agreement that was finally concluded with Bauchet. It stipulated that at the site on which the plant was to be set up conditions were to be as follows:

Maximum temperature of the air	20°C
Relative humidity	90%
Minimum temperature of the air	5°C
Maximum temperature of the water	15°C
Nature of the water	pH between 6.5 and 7.2, free from heavy metals, and from bacteria and fungi capable of liquefying gelatin

Less favourable environmental conditions would have involved higher costs. For example, in the clarifications to the agreement it was stated that for an increase in the temperature of water from 15° to 20°C, the additional cost of equipment would be around $122,000; for an increase in the temperature of the air from 20° to 30°C an additional investment of $531,000 would be required; and for an increase in the temperature of both water and air as above, the increase in investment would be about $735,000. Similarly, if water treatment was needed to remove bacteria or fungi, the increase in investment was estimated at around $281,000. Ooty was considered favourably also because of the relatively dust-free atmosphere, an essential for the manufacture of photo-sensitized products. The readiness with which the local government (State of Tamil Nadu) offered the required land free of cost also tilted the balance in favour of Ooty.

Thus technical considerations apparently prevailed over economic considerations in the choice of location.

One of the major problems in implementing the project proved to be the inordinate delay in commissioning the plant, and the choice of location seems to have contributed to the delay. Difficulties in transporting the building materials and equipment from the plains and the extremely hard working conditions in a remote hill station were underestimated when the construction schedule was drawn up. The emulsion block had to be redesigned because of the difficulty in driving piles to the rock level. Likewise, the effects of the monsoons on the weather for most of the year and the limited working season were inadequately taken into account. The HPF management subsequently admitted that these difficulties should have been foreseen. HPF could also have anticipated high annual costs of transportation, considering that the major centres of consumption of HPF products were Bombay and Madras and that the sources of inputs were also far from Ooty.

A detailed economic analysis of alternative locations, including the transport costs for plant and machinery, raw materials and finished goods, in addition to the costs of controlling the environmental conditions, might have still favoured Ooty, but such an analysis was never made.

Early history of the company

In its early years, HPF appeared to be a failure. Its financial performance was poor. Production began in 1969/70, but two years later its entire equity was wiped out by its accumulated losses. The average annual loss for the first seven years of production was about Rs 24 million. The equity of Rs 53.5 million with which the company was started fell to a negative figure of Rs 139 million by the end of 1974/75, despite two minor infusions of further capital. HPF attracted severe criticism from the press, parliament and the public. In 1972, it had the dubious distinction of ranking as one of the top 10 losers among public-sector manufacturing enterprises. Even as late as 1973/74, it attracted criticism from the Committee on Public Undertakings (CPU).[1]

In 1974/75, however, the company received a major infusion of capital – Rs 100 million. The next year it registered a profit of Rs 1.6 million, and the press now cited it as a "classic case study for public-sector watchers. Sick for eight years . . . almost given up in favour of a . . . new and costlier project, HPF has registered an amazing recovery."[2] It was further noted that the HPF "miracle" was achieved without a change in management or technology.[3] In 1976/77, it recorded a profit of Rs 14.3. By April 1977 the equity of (–) Rs 139 million had been brought up to (–) Rs 14 million. The net worth, however, is still negative.

In its Annual Report for 1976/77, the HPF management called attention to the company's position as one of the six companies in the world manufacturing the entire range of photo-sensitized goods (cine, X-ray and roll film). It maintained that India had achieved self-sufficiency in photo film. It pointed out that HPF X-ray film was used in all hospitals in India.

Tables 1 and 2 give the summarized income statements and balance sheets for the period 1967-1977. Table 3 shows the annual changes in equity since production began. Figure I presents the profit-and-loss position for the period 1967-1977.

Statistics on sales and production round out the picture. The value of annual sales increased from Rs 8.9 million in 1967/68 to Rs 312.7 million in 1976/77 (see figure II). Sales figures for the same period are given in table 4.

[1] *Fifty-fifth Report*, CPU No. 264 (Committee on Public Undertakings, Fifth Lok Sabha, April 1974). Henceforth referred to as *CPU Report* (April 1974).

[2] "HPF – An amazing record of recovery", *Business Standard*, 23 May 1976.

[3] "Sick baby to a healthy one", *Deccan Chronicle*, 8 February 1976.

TABLE 1. SUMMARIZED INCOME STATEMENTS, 1967-1977

(Thousands of rupees)

Item	*1967/68*	*1968/69*	*1969/70*	*1970/71*	*1971/72*	*1972/73*	*1973/74*	*1974/75*	*1975/76*	*1976/77*
Revenue										
1. Net sales	8 863	22 918	37 212	36 571	43 636	52 917	78 323	139 344	222 755	312 039
2. Other	218	518	861	710	1 056	684	619	628	806	2 689
3. Total (1+2)	9 081	23 436	38 073	37 281	44 692	53 601	78 942	139 972	223 561	314 728
Expenses										
4. Cost of materials	3 957	19 038	26 124	26 936	30 330	39 608	55 223	98 770	164 308	264 145
5. Salaries, allowances etc.	4 416	5 650	7 176	9 160	10 418	11 841	14 003	17 020	20 289	23 905
6. Payments to collaborators	121	47	912	1 794	2 147	104	–	–	236	51
7. Electricity charges	1 242	1 150	1 236	1 423	1 554	1 871	2 044	2 776	3 807	5 762
8. Maintenance and repairs	336	447	802	1 659	1 422	1 910	1 682	2 584	2 760	3 971
9. Laboratory and research	253	347	398	404	308	370	364	561	1 005	1 080
10. Interest	4 943	7 222	8 368	10 664	12 635	14 247	16 616	22 615	20 651	29 332
11. Depreciation	7 873	7 969	8 045	8 093	7 939	8 009	8 207	5 728	4 120	4 429
12. Write-off of stocks	–	–	–	–	–	2 400	1 140	586	670	2 990
13. Administrative sales etc. and adjustments	1 174	2 324	3 967	4 458	3 631	4 752	5 120	6 185	4 373	7 302
14. Total (4 to 13)	24 315	44 194	57 029	64 591	70 384	85 112	104 399	156 825	222 219	342 967
15. Net profit (loss) (3 – 14)	(15 234)	(20 758)	(18 956)	(27 310)	(25 692)	(31 511)	(25 455)	(16 853)	1 342	(13 719)
16. Add (deduct) provisions (net)	200	316	(1 534)	(2 615)	(807)	1 778	(1 866)	112	264	(544)
17. Profit (loss) carried forward	(15 034)	(20 442)	(20 490)	(29 925)	(26 499)	(29 733)	(27 321)	(16 741)	1 606	(14 263)

Source: Reconstructed from the *HPF Annual Reports*.

Note: There may be some errors in reconstructing the statements, since classifying, grouping and reporting varied from year to year, particularly in later years.

TABLE 2. SUMMARIZED BALANCE SHEETS, 1968-1977[a]

(Thousands of rupees)

Item	*1968*	*1969*	*1970*	*1971*	*1972*	*1973*	*1974*	*1975*	*1976*	*1977*
Assets										
1. Cash and bank balances	731	518	1 240	3 319	1 116	1 535	672	6 093	8 691	6 177
2. Sundry debtors	2 706	7 506	9 598	8 872	11 940	22 954	33 113	46 570	25 958	19 249
3. Stocks	23 842	33 347	46 934	55 931	64 851	61 316	64 589	94 590	120 266	172 562
4. Loans, advances and deposits	2 410	1 707	1 941	2 249	1 934	4 606	2 429	4 910	9 575	15 371
5. Investments	163	163	9	9	12	166	167	167	167	217
6. Net fixed assets	92 136	85 629	78 244	71 521	63 860	57 814	51 732	47 194	47 558	53 071
7. Deferred charges (net)	7 670	7 670	6 136	4 602	3 068	1 534		415	11 620	12 427
8. Accumulated loans	21 612	42 055	62 449	92 363	118 861	148 595	175 915	192 656	191 050	176 787
	151 270	178 595	206 551	238 866	265 642	298 520	328 617	392 595	414 885	455 861
Liabilities and equity										
9. Current liabilities	6 775	15 666	16 259	29 604	25 498	26 856	29 817	64 915	84 961	63 998
10. Unsecured loans	73 166	89 565	107 931	116 075	147 630	168 050	194 440	[illegible]	109 604	116 855
11. Secured loans	17 829	15 164	24 161	34 987	34 314	40 414	41 [illegible]	44 599	60 120	111 808
12. Share capital	53 500	58 200	58 200	58 200	58 200	63 200	63 200	63 200	163 200	163 200
13. Reserve and surplus	–	–	–	–	–	–	–	–	–	–
	151 270	178 595	206 551	238 866	265 642	298 520	328 617	392 595	417 885	455 861
14. Net worth (12 – 8)	31 888	16 145	(4 249)	(34 163)	(60 661)	(85 395)	(112 715)	(129 456)	(27 850)	(13 587)
15. Additional infusion of capital	–	4 700	–	–	–	5 000	–	–	100 000	–

Source: HPF Annual Reports.

Note: There may be some errors in the figures, since the format for classifying, grouping and reporting data varied from year to year, particularly in later years.

[a]As on 31 March.

TABLE 3. CHANGE IN EQUITY SINCE PRODUCTION BEGAN

(Thousands of rupees)

	Value	
Item	*Negative*	*Positive*
Share capital as on 1 April 1968		53 500
Accumulated losses as on 1 April 1968	21 612	
Net worth as on 1 April 1968		31 888
Subsequent changes		
Loss		
1968/69	20 443	
1969/70	20 394	
1970/71	29 914	
1971/72	26 498	
1972/73	29 734	
1973/74	27 320	
1974/75	16 741	
Profit		
1975/76		1 606
1976/77		14 263
New capital		
1968/69		4 700
1972/73		5 000
1974/75		100 000
Subtotal	171 044	125 569
Total	45 475	
Net worth as on 1 April 1977	13 587	

Source: Computed from *HPF Annual Reports.*

Although the installed capacity of production was 6.15 million m^2, HPF reached its rated capacity only in 1976/77. After initial production difficulties had been finally surmounted, by 1973, growth was dramatic. Production jumped from 0.9 million m^2 in 1967/68 to 9.2 million m^2 in 1976/77 (see figure III). Though production in 1975/76, 7 million m^2 (see table 5), also exceeded rated capacity, it was partially achieved through conversion of jumbo rolls. Even excluding jumbo-roll conversion, production exceeded rated capacity in 1976/77 by 13%.

These dramatic changes reflect the trials, failures and successes of the enterprise's efforts to acquire and assimilate technology.

Change in Bauchet's ownership

In May 1963, Bauchet was acquired by the Minnesota Mining and Manufacturing Company (known as 3-M), United States of America. The new management reviewed Bauchet's collaboration agreement with HPF and concluded that it would be impossible to expect that a given formula and its manufacturing instructions could be faithfully reproduced in a different country with slightly different machinery. It also concluded that the former management of Bauchet had lacked:

(a) Financial and technical resources;

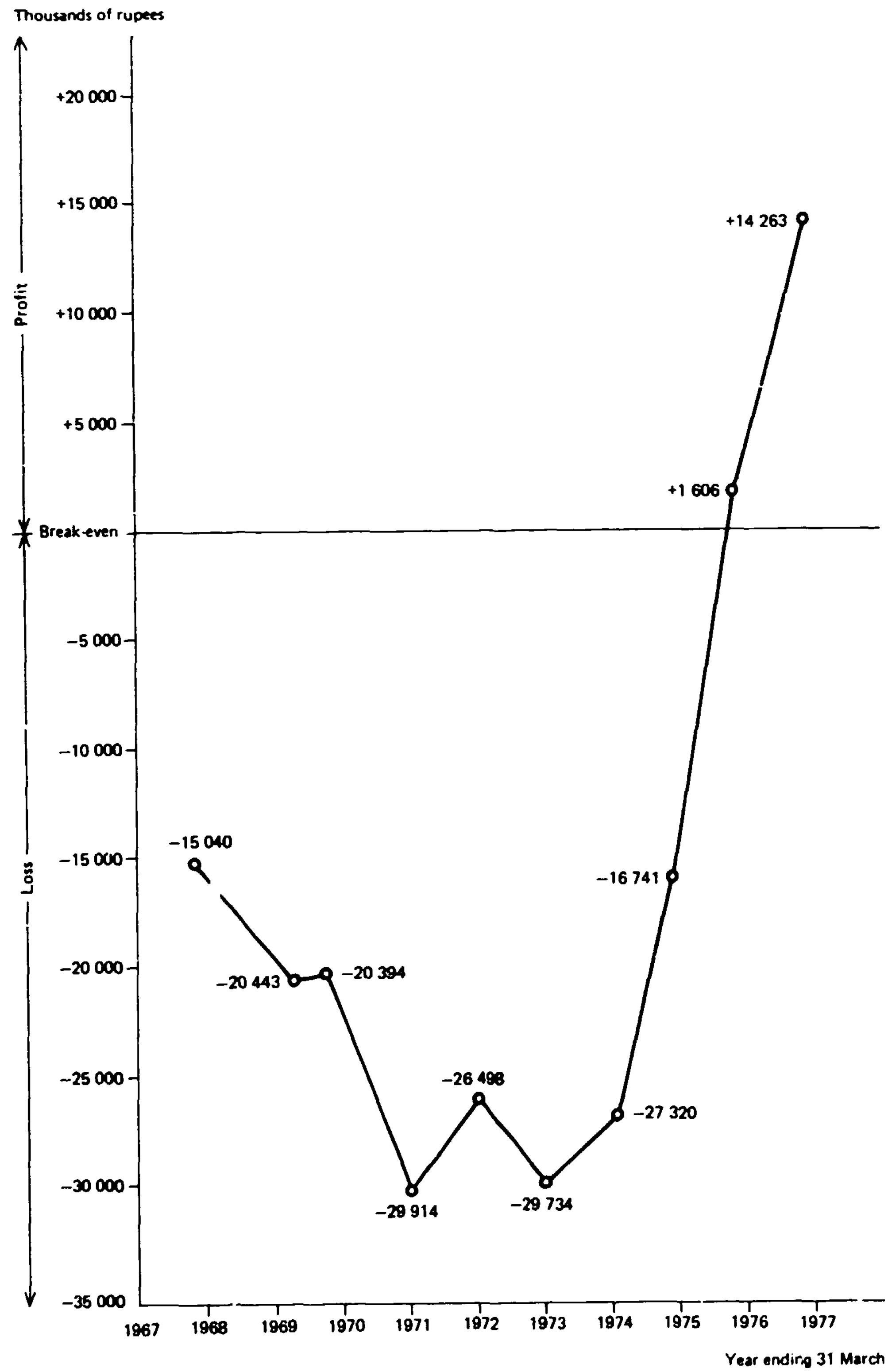

Figure I. Profit-loss position, 1967-1977

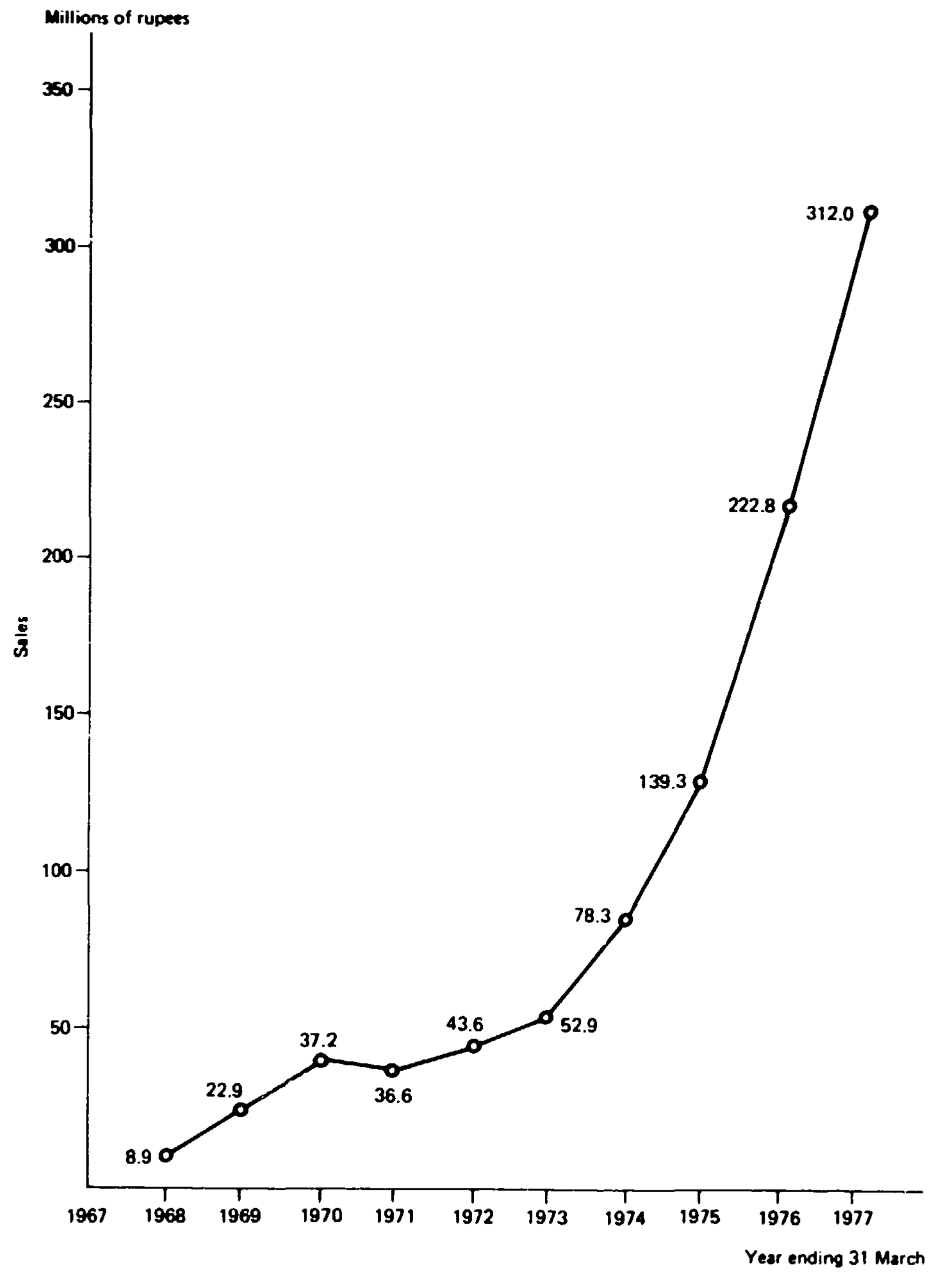

Figure II. Annual sales, 1967-1977

TABLE 4. DOMESTIC AND EXPORT SALES (NET), 1968-1977
(Thousands of rupees)

Sales	*1968-69*	*1969-70*	*1970-71*	*1971-72*	*1972-73*	*1973-74*	*1974-75*	*1975-76*	*1976-77*
Domestic									
Cine film positive	14 233	22 781	14 761	16 626	25 503	28 983	40 514	40 591	51 671
Cine sound		45	616	364	997	4 295	6 233	7 693	9 198
Cine colour positive (jumbo-roll conversion)	–	–	–				20 088	51 178	76 028
X-ray (HPF and jumbo-roll conversion)	7 142	11 752	8 955	14 280	15 300	27 433	46 839	71 557	98 583
Bromide paper	308	1 515	10 672	10 921	10 071	15 173	18 364	34 592	45 717
Roll film	–	12	45	45	31	1 310	6 277	15 815	28 795
Other	1 036	946	1 263	1 151	678	1 116	1 029	1 329	2 164
Subtotal	22 719	37 051	36 312	43 387	52 580	78 310	139 344	222 755	304 156
Export									
Cine film	119	161	258	249	337				
Gelatin	–	–	–	–				–	2 179
Bromide paper	–	–	–	–		9			
Graphic arts	–	–	–	–	–	4			
Silver nitrate	–	–	–	–	–	–	–		5 662
X-ray (polyester base)	–	–	–	–	–	–	–		41
Subtotal	119	161	258	249	337	13	–	–	7 882
Total	22 838	37 212	36 571	43 636	52 917	78 323	139 344	222 755	312 038

Source: HPF *Annual Reports.*

Note: There may be some errors in the figures, since the format for classifying, grouping and reporting data varied from year to year, particularly in later years.

TABLE 5. PRODUCTION DATA

Products	*Rated capacity: As per DPR*	*Rated capacity: As modified by management*	*1967/68*	*1968/69*	*1969/70*	*1970/71*	*1971/72*	*1972/73*	*1973/74*	*1974/75*	*1975/76*	*1976/77*
A. Total production including jumbo-roll conversion (1 000 m^2)												
Cine positive (black-and-white)	2 980	2 450	799	977	1 618	1 056	1 616	1 424	1 505	1 842	1 600	2 172
Cine positive (colour)	–	–	–	–	–	–	–	–	–	547	1 342	1 781
X-ray film	500	1 000	115	169	357	320	346	678	585	893	1 423	2 044
Roll film	220	450	–	–	5	9	2	–	20	87	196	351
Bromide paper	1 600	1 500	1	100	142	1 065	1 320	725	1 231	1 079	2 109	2 319
Portrait and graphic arts film	150	100	–	–	0.1	3	4	1	13	1	5	12
Cine sound film	240	300	–	–	30	22	24	105	150	248	314	403
Cine negative film	180	250	–	–	–	–	–	–	–	–	–	–
Others	–	–	–	–	100	63	–	–	31	–	28	97
Total	5 770	6 050	915	1 246	2 250	2 538	3 312	2 933	3 535	4 697	7 017	9 179
Total production as a percentage of rated capacity as modified by management			15%	20%	37%	41%	54%	48%	57%	77%	114%	149%
B. Jumbo-roll conversion (1 000 m^2)												
Cine positive (colour)	–	–	–	–	–	–	–	–	–	547	1 342	1 781
X-ray film			115	119	–	163	10	233	13[illegible]	553	670	–
Roll film			–	–	–	–	–	–	20	87	196	351
Others			–	–	102	73	15	31	92	26	33	109
Subtotal			115	119	102	241	25	264	244	1 213	2 241	2 241
C. Integrated production (A – B)	5 790	6 150	800	1 127	2 148	2 297	3 287	2 669	3 289	3 500	4 776	6 938
Integrated production as percentage of installed capacity			13%	18%	35%	37%	53%	43%	53%	57%	78%	113%

Sources: HPF *Annual Reports, CPU Report* (April 1974); and internal documents.

Note: There may be some errors in the figures, since the format for classifying, grouping and reporting data varied from year to year, particularly in later years.

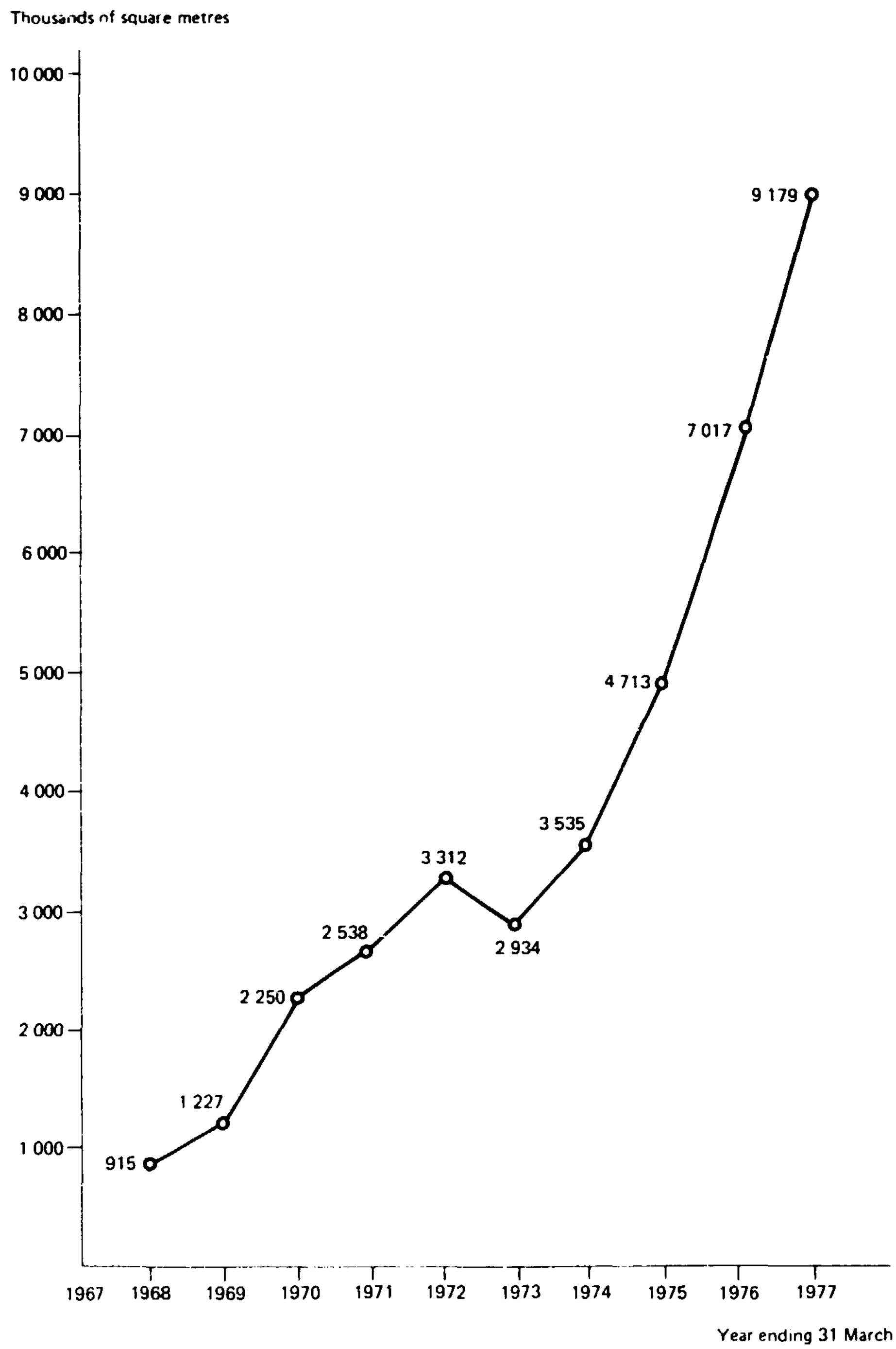

Figure III. Annual production, 1967-1977

(b) Ability to design a modern photographic plant;

(c) Confidence in supplying the technical knowledge for products not commercially produced by them at their plant, e.g., X-ray film, but which had been included in the agreement;

(d) A design and engineering organization capable of coping with the problems that might arise during the erection of the plant.[4]

It also found several deficiencies in the agreement, including apparent contradictions in the clauses relating to carrying out the acceptance tests. (Since acceptance tests are vital in the technology transfer, this subject will be dealt with separately later.)

To resolve disputes regarding the duties and responsibilities of the collaborating parties, 15 meetings were held between the new management of Bauchet and HPF from June 1963 to January 1967. The agreement was also modified with reference to the varieties and quantities of the products to be manufactured and the conditions for conducting the acceptance tests.

Choice of products

The original collaboration agreement envisaged the manufacture of the following products:

- Cine film positive
- Sound cine film
- Cine film negative 100 ASA
- Flat cine film 100 ASA
- Roll film 50 ASA and 100 ASA
- Graphic arts film orthochromatic and non-ortho
- X-ray film rapid and screen types
- Aero film for high-altitude photography
- Bromide, chloromide and document copying papers in various grades of contrast
- Colour paper

Perhaps because the impetus to set up HPF came from the Film Enquiry Committee's report, the original agreement and the DPR emphasized cine film positive. X-ray film, some negative material and photographic paper were expected to be taken up only in the third year, with full production of these to be reached in the fifth year. The views of government experts indicated the need to emphasize X-ray film and to increase the capacity for roll film.

Early in 1961, the Government set up a committee of experts in film and photographic materials to advise the company on the grades of products to be manufactured in the factory. On the recommendation of the committee, HPF began to import small quantities of various products from France to make Indian users familiar with the type of product HPF planned to manufacture. By 1966, the company's market research indicated the need to emphasize X-ray film and to increase the capacity for roll film. Therefore, the company negotiated with 3-M a change in the product mix in favour of X-ray film even though Bauchet did not possess the necessary technology. The capacity as envisaged in the project report in 1960 and the revised capacity agreed upon in November 1966 are given in table 6.

TABLE 6. CHANGE IN PRODUCT MIX AND CAPACITY
(Millions of square metres)

Item	*Capacity as per DPR*	*Revised capacity*
Cine film positive (black-and-white)	2.98	2.45
X-ray film	0.50	1.00
Roll film	0.22	0.45
Flat (portrait) film	0.15[a]	0.05
Bromide paper (3 grades)	1.50[b]	1.50
Graphic arts film	–	0.05
Sound cine film	0.24	0.30
Cine film negative	0.18	0.25
35mm negative film	0.02	0.10
	5.79	6.15

[a]Including graphic arts film.
[b]Including all photographic papers.

The revised product mix, while eliminating a few products of small commercial value, resulted in an increase in production from the originally planned 5.79 million m^2 to 6.15 million m^2.

Meanwhile, 3-M had also acquired Ferrania, an Italian firm that specialized in manufacturing X-ray film. To fulfil the contractual obligations of the earlier management of Bauchet, 3-M agreed to transfer Ferrania's X-ray know-how to HPF. That some American units had also adopted Ferrania's technology in manufacturing X-ray film shows that HPF received a fair deal.

For the HPF management the main reasons for wishing to change the product mix were:

(a) It was advantageous to concentrate on establishing full production of a limited number of products that commanded a good market;

(b) The project would stand on a sounder footing. The annual sales value of the products as per revised product mix was estimated at Rs 10 crores (at the same level of prices) as against Rs 7.94 crores according to the original stipulations;

(c) The production of X-ray film could be undertaken two years earlier than planned, which was

[4]*CPU Report* (April 1974), p. 9.

advantageous to the company in view of the heavy demand for this item;

(d) The production of roll film (another important product) could be undertaken soon after the production of X-ray film (under certain conditions to be agreed upon).

Before HPF began its regular manufacturing activities, its management realized that the total demand in the country for its products would exceed even the revised 6.15 million m^2 capacity.

Diversification of the existing range of products to include cine colour film positive was also contemplated as early as 1966/67. However, even after a decade, HPF had not acquired or developed the technology for colour film, owing to the huge investment necessary and its decision to expand its capacity to produce X-ray film.

Acceptance tests

The acceptance tests as contemplated in the original collaboration agreement were as follows:

(a) For film base. Performance tests were required to be carried out for (i) 24 consecutive hours as regarding the quantity produced (input-output relationship specified), and (ii) for 8 subsequent days as far as solvent consumption was concerned;

(b) For emulsion. Same as above for 24 consecutive hours;

(c) For finishing. Same as in the case of film base, for 8 consecutive hours;

(d) For characteristics and general quality. Acceptance based on producing a minimum of 300 of each product.

A controversy arose regarding the acceptance tests for characteristics and general quality. The new management of the collaborating firm informed the company in February 1964 that to adapt all the products to local conditions would require substantial development work and would thus take several years. It therefore suggested that the agreement be modified so as to limit the performance tests for characteristics and quality to only two products, namely, cine film positive and X-ray film, instead of each of all the products as originally provided for. After discussions, the products were divided into three categories and the collaborator's responsibilities were also modified as shown below.

Product	*Collaborator's responsibility*
List A	
Cine film positive (black-and-white – one grade) X-ray film (one grade)	Two samples of 300 m^2 each to be produced, start of production established and technological operation documentation to be supplied
List B	
Roll film (one grade) Leica film (one grade) Flat (portrait) film (one grade) Bromide paper (three grades)	Two samples of 300 m^2 to be produced for testing of characteristics of general quality and technological operation documentation to be supplied
List C	
Graphic arts film (orthochromatic and non-ortho) Sound cine film Cine film negative Aero film for high altitude photography Chlorobromide paper (four grades) Document copying paper (by contact and by enlargement) Bromide paper (two grades) Colour paper	Only technological operation documentation to be supplied. The formula not guaranteed, since it had to be developed and adapted to Indian conditions by the company

The importance of these three categories can be gauged from the subsequent struggles of HPF to master the technology of products in the B and C lists.

In terms of the degree of sensitivity of products and complexity of technology, X-ray film was found at the high end of the scale among the following products (according to the senior technical officials of HPF):

Paper (least complex)
Cine positive (black-and-white)
Cine sound
Cine negative
Roll negative
X-ray (most complex)

X-ray film needed high grain coating as against the fine grain coating needed by others. It used costly silver halides and needed coating on both sides. Although its technology was more complex than that for cine negative film and roll film, HPF mastered it. Thus, whereas X-ray film was a list A item in the collaborator's acceptance test list, for which the collaborator had the maximum responsibility for transfer, HPF tried and failed to master the technology for roll film, a list B item. HPF did succeed in producing very small quantities of roll film during 1970-1972, but the rejection levels were extremely high. HPF did not undertake to manufacture cine negative film, a list C item, for which technical documentation alone was received. At least in these three cases the company's degree of success seemed to be directly related to the extent of technology transfer from the collaborator. The HPF management's judgement about the complexity of the technology seems to be confirmed by the fact that bromide paper, a list B item, was easily mastered by HPF soon after production began.

Project delays and costs

The original collaboration agreement with Bauchet established a detailed schedule for the construction and completion of the plant, according to which the final stage of acceptance tests should have been completed in 37 months, i.e., by November 1963. However, there was a delay of about five years in completing the acceptance tests, and the plant was finally handed over to the company in October 1968.

The delay in completion of the project has been attributed to:

- Extremely difficult working conditions in a remote hill station
- Unexpected soil conditions
- Difficulty in transporting materials
- Delay in the receipt of detailed plans from the collaborator
- Delay in civil construction
- Change-over in the ownership of Bauchet and the resulting series of meetings with 3-M to iron out controversial clauses in the agreement
- Delay in the supply of equipment by the collaborator
- Time spent in rectifying defects in the equipment supplied

CPU, which investigated this delay in great detail, conceded that the problems related to the change-over in the management of Bauchet were legitimate causes for part of the delay. However, it felt that a more alert management would have recognized the importance of the environment and that with a strong project team right from the beginning some of the problems could have been handled better.

The inordinate delay in the project completion also seems to be the major cause for the substantial increase in the project costs. The project estimates originally prepared in June 1961 came to Rs 60.8 million. They were later revised by the company in June 1962 to Rs 83.8 million, in May 1964 to Rs 116.4 million and finally in February 1971 to Rs 117.0 million. Table 7 gives the details of these revised estimates. Apart from the first major revision, to cover the cost of a workers' housing colony (Rs 10 million), which was not included in the original estimates, most of the subsequent upward revisions seem to be related to the delay in executing the project. Inflation (accentuated by the delay), the devaluation of the rupee and the rectifying of defects in the equipment supplied also played a role.

It should be pointed out, however, that almost all new projects in India suffer from delays in execution, with a consequent increase in costs for most of the reasons mentioned in the case of HPF. Additional procedural delays may occur, at the government level. Furthermore, the effect of the increase in the project costs on the commercial viability of the project was not examined. Here again, the immediate technical problems seem to have been

TABLE 7. PROJECT COSTS

(Thousands of rupees)

Item	*Cost as per project report (June 1961)*	*Revised cost as per June 1962 estimates*[a]	*Revised cost as per May 1964 estimates*[b]	*Revised cost as per February 1971 estimates*[c]	*Actual expenditure as on 31 March 1973*
Plant and equipment	35 387	36 550	51 202	51 906	51 152
Land and buildings	11 315	17 600	18 261	17 883	17 820
Local services	5 137	7 745	12 803	14 194	14 649
Administrative expenses	–	1 285	9 472	9 654	9 654
Training expenses	–	600	645	558	558
Start-up and training	–	1 000	1 645	1 500	1 500
Interest payable to collaborator	9 000	9 000	7 995	8 217	8 217
Interest on loan capital	–	–	2 670	2 670	2 670
Workers' housing colony	–	10 000	10 000	8 570	8 627
New schemes	–	–	1 748	1 871	1 871
	60 839	83 780	116 441	117 023	116 718

Source: Fifty-fifth Report, CPU No. 264 (Committee on Public Undertakings, April 1974).

[a] Approved by Government in August 1962.

[b] Approved by Government in June-September 1967.

[c] Approved by Government in January 1973.

given greater weight than long-term economic considerations, something that seems to be particularly true of public-sector projects in India.[5]

Assimilation of technology

Evidence that a manufacturing firm has assimilated technology takes many forms. This case-study will concentrate on three:

Improvement in productivity

Production of import substitutes

Creation of new products and processes (research and development)

Before examining these three aspects in detail, one should have a fair understanding of the manufacturing process.

Manufacturing process

The factory consists of four major production departments:

Film base

Emulsion

Coating

Conversion

The manufacturing process in these four departments is described in annex II.

In the film base department, cellulose triacetate, dissolved in methylene chloride and methanol, is continuously cast on a belt of stainless steel to form the film bases of different thickness over which the photo-sensitive emulsion will be coated. The resulting safety film base is then treated in a substrating operation to ensure perfect adhesion of light-sensitive materials. In the emulsion department, the emulsion of silver nitrate is prepared by adding it to a solution of alkali halides and gelatin. In the coating department, the emulsion is coated on the substrated base received from the base casting department. Finally, the coated film in jumbo rolls is sent to the conversion department, where the very broad and long films are slit to the required width and length, perforated, wound and packaged.

Productivity

Capacity utilization

As mentioned earlier, on completion of the tests the plant was handed over to the HPF management in October 1968. The production of cine film positive had started in June 1967 and X-ray film in May 1968. Regular production of bromide paper started soon after the HPF management took over. Though the first year of manufacturing was 1967/68, production remained far below capacity until 1973/74 (see table 5).

In 1975/76 and 1976/77, production jumped; the output of X-ray film, bromide paper and cine sound positive exceeding the rated capacity. HPF performance showed the most dramatic improvement with respect to X-ray film; its production in 1976/77 was more than twice the rated capacity (see table 5). The first seven years were really the years of struggle; all the problems in assimilating technology showed up during this period.

CPU closely questioned the HPF management regarding the poor output for the first seven years of manufacturing. The management gave the following reasons for the shortfall:[6]

(a) The plant and equipment were designed by the collaborator, who was not entirely familiar with the technology built into the design. The collaborator also finished know-how for delicate products like X-ray film that had not been produced in its own plant;

(b) The plant was designed essentially for the production of cine film positive, although the manufacture of other types of photographic film and paper was also planned;

(c) The plant and machinery were subjected to a series of improvisations by the collaborator. In addition, serious machinery breakdowns delayed the commencement of production;

(d) The company embarked upon a vigorous programme of accelerated import substitution. Although in some cases the company was successful, in others serious technical problems arose;

(e) Indian consumers, being accustomed to the use of high-grade imported brands, insisted that the company upgrade quality from the very beginning, which meant that development work had to be started simultaneously with commercial production, with a tight schedule to carry out improvements expeditiously;

(f) The determination of the rated capacity assumed certain levels of rejection, whereas the actual rejections were much higher;

(g) There were teething troubles in the development of certain processes. As a result, an imbalance occurred between one set of processes and another;

(h) Some amount of underutilization of capacity was due to failure to receive raw materials from abroad (methylene chloride and gelatin in 1967/68 and cellulose triacetate in 1967/68 and 1970/71);

(i) It is one of the peculiarities of the photographic industry that all equipment for all

[5] See, for example, *Fifth Report of the Public Accounts Committee on New Services and New Instrument of Service* (Fourth Lok Sabha), paras. 1.7 and 1.9; *Thirty-ninth Report on Pyrites, Phosphates and Chemicals Ltd.* (Committee on Public Undertakings, 1972/73), para 2 20.

[6] *CPU Report* (April 1974), pp. 43-44.

products, including those to be developed in future, have to be installed in the factory premises before any equipment is commissioned. A large part of the underutilization of equipment occurred because the products for which the equipment was intended were still to be developed or were in the process of development or (going through) teething troubles;

(j) Output fell below rated capacity, partly because some of the products failed to meet specifications and were rejected for not fulfilling the specifications and partly because production difficulties arose in certain operations.

Thus, at least part of the delay could be attributed to the collaborator. However, the other problems reflect the internal difficulties in absorbing technology. One definite indicator of how well technology is being absorbed is the trend in rejection levels.

In-process rejections

One of the main reasons for the shortfall in production was the heavy in-process rejections. Table 8 summarizes the trend in the rejection levels since 1968/69. For the three main products the rejection levels for 1968/69 were as follows (percentage of inputs):

Cine positive	50.9
X-ray film	67.7
Bromide paper	40.6

In 1970/71, which was one of the worst years, the rejection levels for cine positive and X-ray film reached an all-time high of 60.4% and 81.6%, respectively, while the rejection level for bromide paper, a lower technology item, improved to 13.8%. An analysis by department indicates that maximum rejection occurred in base casting (including substrating), though in the case of X-ray, it was in conversion.

In a continuous process, a high rejection at the conversion stage may indicate that problems either occurred there or had occurred earlier and were not revealed until the conversion stage. If the in-process quality control measures at the earlier stages are not stringent enough, there is a high chance of rejections at later stages.

In 1970/71, two base casting machines had to be modified to suit the specifications of the indigenous cellulose triacetate.

Although an analysis of the trend in rejections by product and department shows some fluctuations, a definite improvement can be seen since 1972/73. According to company executives, an overall systems improvement contributed to the reduction in wastage and an increased yield.

TABLE 8. REJECTION LEVELS

(Percentage of total input)

Product and department	*1968/69 Actual*	*1969/70 Actual*	*1970/71 Actual*	*1971/72 Actual*	*1972/73 Actual*	*1973/74*		*1974/75*		*1975/76*		*1976/77*		*Budget for 1977/78*
						Standard	*Actual*	*Standard*	*Actual*	*Standard*	*Actual*	*Standard*	*Actual*	
Cine positive														
Base casting	14.4	[illegible]	35.3	27.0	14.5	10.0	19.1	10.0	15.1	10.0	17.7	10.0	6.6	6.5
Substrating	13.9	[illegible]	20.8	9.7	10.5	7.0	7.9	7.0	10.4	7.8	4.3	6.0	3.1	3.0
Coating	9.1	5.9	2.8	3.4	7.1	2.0	3.2	4.5	6.1	4.5	7.7	4.5	7.3	4.4
Conversion	26.7	19.9	19.8	15.9	11.6	10.0	12.0	10.0	9.1	10.0	15.6	10.0	12.5	9.3
All types	50.9	46.1	60.4	46.4	37.2	26.2	36.5	28.1	35.1	28.1	38.7	27.3	26.5	21.4
X-ray film														
Base casting	22.1	33.6	33.5	23.3	21.5	13.0	29.1	13.0	15.2	13.0	10.9	12.0	7.6	7.0
Substrating	8.1	29.9	19.2	10.3	10.5	7.0	7.9	6.0	6.3	6.0	4.4	6.0	3.3	3.0
Coating	18.9	15.4	18.2	14.2	22.7	10.0	7.3	16.0	21.5	14.0	22.8	14.0	17.6	13.0
Conversion	43.8	34.6	58.3	38.7	35.7	20.0	36.4	20.0	47.2	23.0	38.0	23.0	26.4	21.0
All types	67.7	71.0	81.6	63.8	65.1	41.7	61.5	45.0	67.1	45.9	59.2	45.2	45.9	[illegible]
Bromide paper														
Coating	22.6	11.7	4.0	6.2	8.2	10.0	3.9	7.0	7.3	8.0	5.5	7.7	6.4	7.0
Conversion	23.2	17.4	10.2	11.6	10.3	10.0	12.0	12.0	10.2	12.0	11.1	10.0	12.1	10.0
All types	40.6	27.0	13.8	16.2	17.6	19.0	15.4	13.2	16.7	19.4	16.0	16.9	17.8	16.3
Cine sound														
Base casting					23.1	10.0	23.5	10.0	17.8	10.0	13.3	10.0	11.1	7.0
Substrating					11.3	7.0	10.3	7.0	15.8	7.0	7.0	6.0	4.1	3.0
Coating					8.5	2.0	12.1	7.0	7.1	7.0	11.5	5.5	6.8	5.2
Conversion					4.9	10.0	19.7	18.0	23.3	22.0	31.9	20.0	22.4	15.5
All types					35.0	26.0	51.3	36.2	50.6	39.3	51.4	36.0	38.3	27.7

Sources: Company records and *CPU Report* (April 1974).

In 1967/68, no detailed records of input-output data were kept. From July 1969, detailed minutes were kept of the weekly meetings held by the production manager indicating the percentages of rejections. However, only from September 1971 on did these minutes record the causes of rejections. Records also show that corrective measures were formally initiated only at the end of 1971/72.

Some of the systems improvements brought into effect in 1973/74 are indicated below:

(a) A standard costing and budgeting control system was introduced along with the tightening of standards (as can be seen from the standards for 1977/78, in table 8);

(b) A standard quality control unit was set up with the help of the Indian Statistical Institute and implemented on a crash programme basis;

(c) Monthly schedules of capacity utilization were formulated;

(d) A new and powerful process control department was set up with staff specifically assigned to assist each production department;

(e) The research and development unit was strengthened;

(f) Four task forces were constituted by the end of August 1972 to work on inventory control, programmed cost improvement, process improvement and new product development;

(g) A systematic effort was made to encourage documentation at all levels, something that was sorely lacking earlier. This partly helped in reducing a repetition of the same mistakes;

(h) Experimentation in all plants under the guidance of senior departmental managers was encouraged.

These and similar efforts not only reduced the rejection levels, but also improved productivity. The output per worker per month shot up from 68 m² in 1967/68 to 370 m² by 1976/77 (see figure IV). All these improvements were achieved with scarcely any additional labour (see table 9). Whatever little increase there was took place in the conversion department to enable it to cope with the massive increase in jumbo-roll conversion introduced in 1974/75.

Of course, it cost something to achieve higher output. There was a steady infusion of capital in the form of additional equipment or modifications to existing plant and machinery. Table 10 shows the yearly additions to fixed assets (buildings, plant and machinery, laboratory equipment and investments in infrastructure). The relatively large investment in 1976/77 includes a project to expand at Ambatturai in Tamil Nadu. Even so, top management obviously supported the improvement efforts specifically by sanctioning additional capital expenditure particularly from 1972/73 on.

To improve the quality and yield, some allowance also had to be made for increased consumption of a few key raw materials like cellulose triacetate and triphenyl phosphate (see table 11). Another dramatic improvement in productivity was achieved by increasing the operating speed in base casting and coating. In most cases the speed was doubled, as shown in table 12.

The manner in which the increase in speed in the two departments was achieved illustrates the cross-transfer of technology from multiple sources. The increase in the speed in base casting was achieved through a combination of knowledge from Bauchet, Ferrania, and later Du Pont and efforts of HPF. The

TABLE 9. LABOUR FORCE

(Number)

Department	Sanctioned strength	Year[a]					
		1973	1974	1975	1976	1977	1978
Film base	171	114	134	122	119	143	164
Emulsion	154	140	145	141	138	119	139
Coating	134	122	135	119	118	118	127
Conversion	298	210	262	269	263	385	391
Civil, mechanical, maintenance and services	426	335	355	363	360	369	394
Laboratory	269	224	231	233	242	267	248
Silver nitrate	80	74	69	70	71	88	101
Purchase and stores	125	115	132	140	138	161	159
Sales	97	78	82	100	101	116	134
Finance and accounts	76	69	78	81	74	75	75
Administration	348	311	325	316	316	328	356
Other	14	13	11	6	7	37	50
Total	2 192	1 805	1 959	1 960	1 947	2 206	2 338

Source: Company records.

[a]As on 31 March.

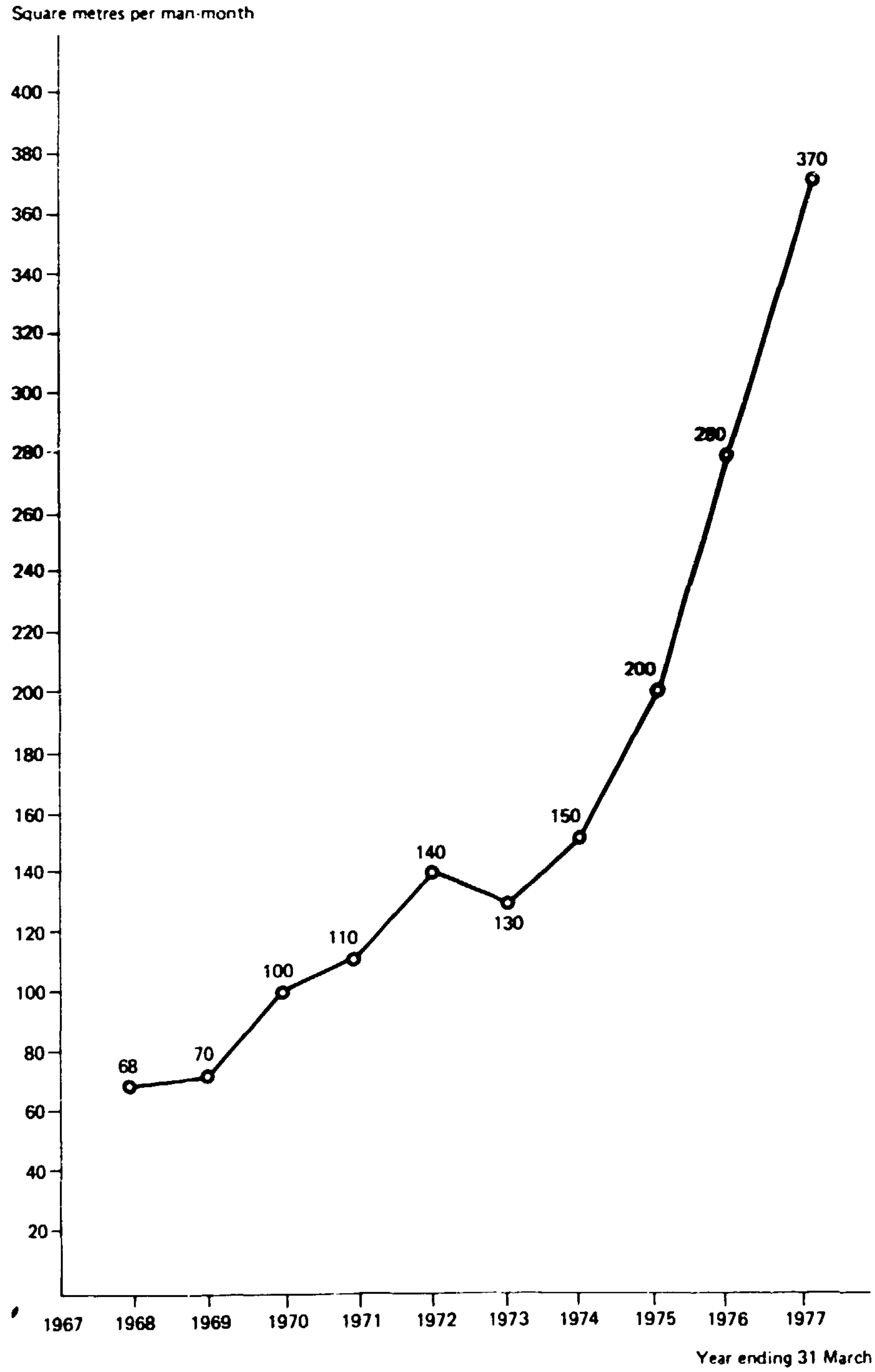

Figure IV. Productivity, 1967-1977

TABLE 10. INVESTMENT IN FIXED ASSETS

(Thousands of rupees)

Year	*Buildings*	*Plant and machinery*	*Laboratory equipment*	*Land, roads, water works, vehicles*	*Total*
1961/62	139	1 174	13	539	1 865
1962/63	4 645	18 016	16	634	23 311
1963/64	6 190	11 298	110	1 937	19 535
1964/65	4 800	8 138	[a]	1 326	14 264
1965/66	5 956	18 125	[a]	1 499	25 580
1966/67	3 084	13 730	[a]	766	17 580
1967/68	1 773	1 097	[a]	481	3 351
1968/69	203	1 063	[a]	204	1 470
1969/70	59	295	[a]	161	515
1970/71	331	760	[a]	308	1 399
1971/72	292	580	[a]	81	953
1972/73	306	1 070	104	179	1 659
1973/74	64	1 979	494	89	2 626
1974/75	94	1 061	23	159	1 337
1975/76	240	2 594	137	282	3 253
1976/77[b]	2 833	2 932	317	1 345	7 427
Total gross investment	31 009	83 912	1 214	9 990	126 125
Depreciation[c]	(−)6 156	(−)58 339	(−)1 992	(−)7 701	(−)74 188
Other adjustments[d]	(−)2 565	(−)7 539	(+)1 884	(+)2 298	(−)5 922
Net assets as on 1 April 1977	22 288	18 034	1 106	4 587	46 015

Source: Adapted from published annual reports.

[a]Not separately reported; included in the figures for plant and machinery.

[b]Including the investment in the new project at Ambatturai.

[c]As per the annual report for the year ending 31 March 1977.

[d]Sales, write-off, reclassification etc. arrived at as a balancing figure.

TABLE 11. CONSUMPTION OF KEY MATERIALS

Materials	*1968/69*	*1969/70*	*1970/71*	*1971/72*	*1972/73*	*1973/74*	*1974/75*	*1975/76*
Base casting								
Cellulose triacetate (g/litre of collodion)	124	130	131	132	134	154	157	179
Triphenyl phosphate (g/litre of collodion)	20	21	22	22	22	25	27	32
Solvent loss (kg/kg of base produced)	...	...	...	1.82	1.77	1.57	1.22	0.97
Substration (average for all products g/m^2 substrated)								
Acetone	46	38	44	50	45	39	45	43
Methylene chloride	6	9	19	19	18	19	22	28
Methanol	21	18	21	21	17	20	25	20
Silver nitrate (g/m^2)								
Cine positive	6.9	6.8	7.5	6.4	7.1	7.2	6.6	6.3
X-ray	20.2	22.0	21.6	19.7	21.9	22.0	20.3	19.3
Paper	3.3	3.2	3.3	3.2	3.5	3.2	3.3	3.3

Source: Company records.

TABLE 12. TREND IN THE OPERATING SPEED

Product	Speed guaranteed by Bauchet	Speed achieved		
		1972/73	1974/75	1976/77
Base casting (m^2/h)				
Cine positive	96	100-110	170-175	180-185
X-ray	67	75-80	110-120	120-130
Coating (m/min)				
Cine positive	10	15	15	15
X-ray	6	5.2	5.2	5.2
Paper P.2	6	6-7	6-7	15

Source: Company records.

same was true for coating speed. A major contribution to the increase in coating speed was the switch-over from dip-coating (a relatively obsolete technology) to air-knife coating. Air-knife coating technology for cine positive was originally obtained from Bauchet. In 1971/72, HPF, through its own efforts, adapted it to coat bromide paper. In 1972/73, HPF tried to adapt it for X-ray film, but many problems arose whose solution required the help of Du Pont. At the moment, HPF is working on using air-knife coating for all its products.

Table 13 summarizes some of the key achievements in various departments.

TABLE 13. DEPARTMENT OR PLANT ACHIEVEMENTS IN PRODUCTION

Department or plant and item	Originally installed	1977/78
Film base		
Operating speed of coating machines		
Cine film positive (m/h)	100	215
X-ray film (m/h)	60	135
Total daily production per machine (tons)	0.5	1
Annual capacity (million m^2)	4.6	9.6
Annual productivity per operative in 1973/74 (m^2)	25 000	64 000
Emulsion		
Annual productivity per operative (units)	320	660
Coating		
Operating speeds		
Cine positive/paper (m/min)	6.2	15-16
X-ray (m/min)	5.2-8	16
Annual productivity per operative (m^2)	32 770	68 245 (est.)
Conversion		
Annual productivity per operative (m^2)	13 000	23 000 (est.)
Silver nitrate plant		
Annual production capacity (tons)	80	150
Annual productivity per operative (units)	580	(1976/77) 1 180

Import substitution

The history of import substitution efforts can be viewed from three aspects: substitution of indigenous finished goods for imported finished goods: indigenous raw materials for imported raw materials; and indigenous spare parts, components and machinery for imported ones.

Table 14 gives imports of photographic materials and HPF output for 1972/73. The entire production of cine positive and X-ray film represents import substitution, since HPF was the only producer. About half of the production of photographic paper is import substitution; the other half represents the share of the market taken away from another private-sector producer.

In 1973/74, HPF management began actively to press the Government to stop importing cine and X-ray film. By 1974/75, its efforts succeeded, and since then HPF can legitimately maintain it has achieved 100% import substitution in these two products.

Where its internal capacity was insufficient (e.g., X-ray) or where it did not possess the technology to manufacture (e.g., colour film), HPF resorted to conversion of imported jumbo rolls. For the jumbo-roll conversion, the end-price for the consumers and margins to the dealers were maintained at the old levels as table 15 shows.

The comparison in table 15 shows there was no effect on jumbo-roll conversion on the consumer and the distributor. The Government lost some duty but achieved more value added within the country, and HPF made some profits. The HPF management, however, realized that jumbo-roll conversion should not be the final aim and that efforts should be made to manufacture all products within the country, both to achieve technological self-sufficiency and to increase the value added within the country. However, for products like colour film, self-sufficiency cannot be achieved in the near future, not only because of the technological complexities, but also because of the massive investment needed.

As for the economics of the import substitution, it is difficult to assess the net foreign exchange saved by setting up units whose products are primarily meant for domestic consumption. There are no major problems in assessing the foreign exchange outflows except for capital investments, where the amortization and depreciation have to be taken into account to study the annual impact. If there are steady exports of all the products, the international prices can be used to assess the foreign exchange inflows. In the case of HPF, exports were infrequent and did not cover all the products. Therefore, an attempt has been made to assess the extent of foreign exchange the country would have spent if it had had to import the same output from foreign sources—the c.i.f. value of production. The results of this computation are presented in table 16. The cumulative savings of

TABLE 14. SOURCES OF FILM SUPPLY

Product	*Imports*		*HPF production*		*Other domestic*			
	Number	*Share of market (%)*	*Number*	*Share of market (%)*	*Number*	*Share of market (%)*	*Total*	
Cine film positive								
1968/69	1 782 725	64.6	977 483	35.4	–	–	2 760 208	100
1969/70	788 381	32.8	1 618 126	67.2	–	–	2 406 507	100
1970/71	956 907	47.6	1 056 178	52.4	–	–	2 013 085	100
1971/72	726 935	31.0	1 615 664	69.0	–	–	2 342 599	100
1972/73	640 000	32.0	1 390 000	68.0	–	–	2 030 000	100
X-ray								
1968/69	490 000	74.4	168 480	25.6	–	–	658 480	100
1969/70	554 000	60.8	356 679	39.2	–	–	910 679	100
1970/71	912 000	74.0	320 053	26.0	–	–	1 232 053	100
1971/72	612 000	63.9	345 556	36.1	–	–	957 556	100
1972/73	1 100 000	[b]	680 000	54.0	–	–	1 250 000	100
Photographic paper								
1969	662 000	24.8	142 000	5.3	1 863 000	69.9	2 667 000	100
1970	754 000	20.5	1 065 000	28.9	1 866 000	58.6	3 685 000	100
1971	508 000	13.3	1 320 000	34.5	1 994 000	52.2	3 822 000	100
1972/73	410 000	12.3	730 000	21.9	2 000 000	59.9	3 340 000	100

Source: Adapted from *Fifty-fifth Report*, CPU No. 264 (Committee on Public Undertakings, Fifth Lok Sabha, April 1974).
[a]Imports are those of agencies other than HPF. HPF jumbo-roll imports are included in its own production.
[b]Percentage is meaningless as there were excessive imports. Supply exceeded demand.

TABLE 15. COMPARISON OF THE ECONOMICS OF JUMBO-ROLL CONVERSION AND IMPORT OF FINISHED GOODS

(Rupees)

Component of price	*Based on jumbo-roll conversion*	*Based on import of finished goods*
C.i.f. cost	173.14	224.14
Customs duty	140.48	172.45
Conversion costs	63.53	–
Other duties and taxes	61.65	65.91
Distributor's margin	39.66	39.66
HPF profit	23.70	–
Retail price	502.16	502.16

foreign exchange up to 1 April 1977 were about Rs 144 million. The accumulated losses of the unit up to 1 April 1977 were about Rs 177 million. Thus, the company can be said to have paid Rs 177 million to save foreign exchange worth Rs 144 million. However, in the process the company learned the technology, and most of the capital equipment is expected to last longer than the depreciation policies would indicate. The project also created direct employment for about 2,000 persons and indirect employment for many more. The indirect employment would primarily be in the units supplying inputs and not in distribution, as several private distribution networks for marketing the imported goods already existed before HPF was set up.

Raw materials

HPF calculated, in 1971, that if all the materials not available in the country when the project began had had to be imported, the c.i.f. value of such materials would amount to about Rs 65 million for an installed capacity of Rs 6.15 million m^2. To reduce such dependence on imported materials, the company undertook detailed studies even while the factory was being constructed. As a first step, a silver nitrate plant and an organic synthesis unit were set up as adjuncts to the factory to meet its total requirements. These units were designed by local experts led by one of the senior managers who had earlier worked in the silver nitrate plant of a foreign manufacturer.

The silver nitrate plant was originally designed with a capacity of 8 tons per month, but by adding necessary equipment its capacity was raised to 12 tons per month. By 1976/77, the silver nitrate output exceeded the company's requirements, and the surplus was exported to the German Democratic Republic and to Hungary. The Du Pont Company also expressed its willingness to buy silver nitrate from HPF.

The organic synthesis unit, which started production in January 1966, was set up to manufacture organic chemicals such as hardeners,

TABLE 16. FOREIGN EXCHANGE OUTFLOWS AND INFLOWS

(Thousands of rupees)

Item	Up to 1972/73[a]	1973/74	1974/75	1975/76	1976/77	Cumulative to 1977/78
Outflows						
Raw materials		9 110	42 460	61 476	73 689	
Components and spares	46 335	1 049	742	554	5 125	240 540
Capital goods (depreciation)[b]	27 545	4 600	3 400	2 500	2 700	40 745
Royalty	5 125	–	–	89	50	5 264
Interest payment	...	238	189	159	101	687
Other	...	3	47	230	276	556
Total outflow	79 005	15 000	46 838	65 008	81 941	287 792
Inflows						
Exports	1 124	13	–	–	7 882	9 019
C.i.f. value of production, excluding exports[c]	125 595	32 987	55 800	88 800	119 818	423 000
Total inflow	126 719	33 000	55 800	88 800	127 700	432 019
Savings	47 714	18 000	8 962	23 792	45 759	144 227

Source: HPF Annual Reports.

[a]Cumulative figures up to 1 April 1973 (except royalty) are taken from the *CPU Report* of April 1974.

[b]For imported machinery, instead of taking actual foreign exchange outflows, the annual depreciation value as estimated by management is taken.

[c]Estimates by management based on the landed cost of equivalent goods until imports were discontinued and subsequently on c.i.f. value.

antifoggants and sensitizing dyes, all of which used to be imported.

Apart from setting up these two ancillary units, the company searched for indigenous manufacturers of raw materials and packaging materials. It spent a considerable amount of time in examining the specifications and testing the samples manufactured by indigenous enterprises. It also maintained liaison with the Directorate General of Technical Development to find out which licences had been issued by the Government and to follow up the projects accordingly. For example, Meattur Chemicals was licensed to manufacture methylene chloride. HPF maintained close contact with it from the very early stages and tested a small batch of the product of its collaborator to determine the suitability of the product when manufactured in India. This work ultimately led to the substitution of indigenous for imported methylene chloride. A similar follow-up with Mysore Acetate and Chemicals Company led to the substitution of another locally produced major raw material, cellulose triacetate, for the imported product.

In October 1968, following a newspaper advertisement, HPF approached the Trombay unit of the Fertilizer Corporation of India and succeeded in obtaining an acceptable quality of methanol from it. A similar approach to the National Organic Chemical Industries in Bombay led to the procurement of locally produced acetone. Certain grades of gelatin, another major raw material, are now being manufactured by Protein Products India Ltd., Ooty, instead of being imported.

In addition, HPF established direct contact with several Indian enterprises to encourage them to produce other raw materials to rigid HPF specifications. In the course of this work, HPF had to give these enterprises detailed specifications and in certain cases small samples of imported materials as well. Dibutyl phthalate manufactured by Indo-Nippon Chemical Company, for example, could not meet HPF specifications. HPF tested a series of samples, each time giving additional information that could help the company to improve the quality. This information ultimately enabled the company to obtain exactly the material needed. Examples of other raw materials now locally manufactured as a result of HPF efforts are potassium bromide, thymol, lithium nitrate, gold chloride, brass matrices, roll-film spools and black wrapping paper.

Some of the projections for the five-year period 1971-1976 have yet to be realized. For example, imported triphenyl phosphate and bicolour paper are still in the process of being replaced by the locally produced items. The effort to produce saponine is still at the research and development stage. The import substitution actually achieved in 1976/77 was 73%. By 1977/78 77% of raw materials used by HPF were produced locally.

For many chemicals needed in small quantities, the major problem in import substitution is not that technology is lacking, but that it is uneconomic to manufacture them in very small quantities. In many cases the HPF requirements are far below the break-even volume, even for a small manufacturer. The HPF annual requirement for triphenyl phosphate is about 150-200 tons, but a much larger volume must be produced to be economic even if the smallest reactor is used.

The import substitution of key raw materials also generated many unexpected production problems. For example, when locally produced cellulose triacetate was used in June 1969 in combination with the imported material in the ratio of 50:50, the elongation of the base cast was found to be poor as compared with that obtained when imported material was used exclusively. By the end of July 1969, when the base made with locally produced material reached the subsequent stages of production, further problems, not anticipated earlier, became apparent. The quality of X-ray material was poor. Static marks were found on X-ray film, and the accumulation of film-base dust on the perforating machine caused scratches on cine film. To overcome these defects, extensive trials were undertaken. As a result, two out of six base casting machines were modified and the remaining four machines de-aerated at a cost of Rs 1.61 lakhs and Rs 2.33 lakhs, respectively. Also, a non-recurring expenditure of Rs 14.99 lakhs on trials and the resulting extra scrap was incurred, and more operators had to be engaged to operate the modified machines. The filtration loss, the solvent loss and the maintenance expenditure also increased and resulted in an additional recurring expenditure of Rs 8.98 lakhs per year. Despite these modifications, the rate of rejections increased during 1970/71 in respect of all products. The company's expectation that locally produced cellulose triacetate could be used without major problems, which was based on tests instead of on full evaluation of the use of the material from the first to the last stage of production, has not, therefore, been realized.[7]

Spares, components and machinery

The major problem in achieving import substitution for spares, components and machinery is again that a low volume of production is uneconomic. Since HPF is the only manufacturer of photo-sensitive products in the country, it is hard to find a manufacturer who is prepared to devote its developmental efforts to manufacturing for this one company.

HPF is making an exhaustive search in the local market for spare parts or components suitable for its imported machines. Every case of procurement is under constant review for possible import substitution, both with regard to the spare and the equipment itself. Substitution effort is being pursued as a general rule except for highly specialized items for which expertise is not available and items of minor value that cost too much to fabricate.

HPF has assisted indigenous enterprises to undertake the manufacture of spares and components by giving them samples, designs and drawings and suggestions for fabrication and for improving quality. Its efforts have been successful in the case of a few items, some of which are:

Special high-precision matrices for 35mm and 16mm film

Special potential transformers for use in the HPF substation

Moulded rubber tubes for squeeze pumps etc.

Rubberized metal wheels for special fork-lifts

Spare parts for perforators

The company's own technical personnel in the production and maintenance departments have continued their efforts to produce local spares, components, and machinery. They developed the blueprint for a new film perforator, combining the knowledge they gained for operating the perforators supplied by Bauchet and other companies. They developed a hand-spooling machine at a cost of Rs 5,000 as compared with an imported machine costing Rs 30,000 and operating at a speed 20% lower. They also made a wooden prototype of the coating trough, which is a rough but modified copy of the trough supplied by Du Pont. These efforts are of recent origin, since the company's technical personnel were earlier preoccupied with solving process problems.

Research and development

Although the company set up a laboratory as early as 1963/64, it functioned initially only as a laboratory to test raw materials, water and other inputs. Aside from a few experiments in emulsion formulation, practically no development work was carried out until 1972/73.

The company did recognize the importance of research and development and its inability to perform much owing to lack of funds. Its total expenditure in this area for 16 years beginning in 1961/62 was about Rs 27.8 million, or an average of Rs 1.7 million per year, broken down as follows (million rupees):

Laboratory and research	5.26
	5.27
Foreign technicians	2.73
Training of Indian technicians abroad	0.69
Other	13.87
Total for 16 years	27.82
Average annual spending	1.74

[7] *CPU Report* (April 1974), pp. 48 and 49.

The research and development on even a single product in the industry is often estimated at several million dollars.

Table 17 shows the staffing of the research and development department—meagre by international standards. It indicates the inability of units of the size of HPF to launch major research and development. Table 18 gives data on five international manufacturers of photographic goods (some of them also produce other items). Even a quick look at the table shows the insignificant size of HPF compared with these giants. HPF is about 0.3% the size of Du Pont, about 0.4% of Kodak and 0.7% of 3-M. Even compared with smaller international units like Polaroid and Fuji, the size of HPF is insignificant (2.5% and 2.9%, respectively). When even firms like Fuji find it difficult to compete technologically with the giants, HPF has very little chance. Yet HPF in its own way has utilized its limited research and development facilities to achieve some results in product and process improvement, new product development and import substitution.

None of the new products developed is strictly new in the sense that it was invented for the first time. The products are new only in that HPF succeeded in manufacturing samples of them without any technical assistance from an outside source. Even though in many cases the production stage has been reached, no product has become of major commercial importance. Research findings suggest that many fruits of research and development efforts usually remain as samples, unless supported by significant market forces. HPF is not likely to be an exception.

The new product development programme is listed below.

1976/77	Document copying paper
	Processing chemicals
	Graphic arts orthochromatic
1977/78	Graphic arts panchromatic
	Industrial X-ray
	Dental X-ray
1978/79	Personnel monitoring film
1979/80	Master positive
	Dupe negative
1980/81	Microfilm positive
	Microfilm negative
	Fluorographic film
1981/82	Colour paper
1982/83	TV reversal film (black-and-white)
1983/84	Multicontrast paper
1984/85	Colour positive film

Problems faced in acquiring and assimilating technology

Interview with Du Pont

To discuss some of the problems arising in technology transfer, a member of the faculty of the Indian Institute of Management visited the head-

TABLE 17. STAFF EMPLOYED IN RESEARCH AND DEVELOPMENT DIVISION[a]

Title	*1972/73*	*1973/74*	*1974/75*	*1975/76*	*1976/77*	*1977/78*
Chief of laboratories and research	1	1	1	1	1	1
Assistant director	2	0	0	0	0	2
Scientific officer	0	3	5	6	8	10
Others	40	37	35	35	39	54
Total	43	41	41	42	48	67

[a]Excluding office staff.

TABLE 18. COMPARATIVE SIZE OF SELECTED INTERNATIONAL PRODUCERS AND HPF

Item	*Du Pont*	*Kodak*	*3-M*	*Polaroid*	*Fuji*	*HPF*
Assets (thousand dollars)	7 017 800	5 516 699	3 324 135	949 616	822 774	24 000
Sales (thousand dollars)	8 361 000	5 538 170	3 514 259	950 632	738 675	24 750
Net profit (thousand dollars)	459 300	650 618	338 520	79 690	32 228	178
Employees (number)	140 900	127 000	79 500	14 500	15 472	1 953
Chief executive's salary (dollars per annum)	616 072	450 895	507 290	320 300	...	Below 4 000[a]

Sources: Forbes, 15 May 1977; *Fortune*, May 1977; *Annual Report of HPF 1976;* and "Caring for our precious assets", HPF pamphlet, undated.

[a]Names and other particulars of executives drawing more than Rs 36,000 ($4 000) per annum must be published in the annual report of the company. HPF had no employees in that category.

quarters of the Du Pont Company in Wilmington, Delaware, the United States, a company with which HPF had dealings, to interview some of the senior executives in the Photo Product Department.

Du Pont officials noted the close scrutiny of HPF by government agencies. In their opinion, no company in the photographic industry would publicly disclose its problems in such detail in a developed country.

Many of the comments on HPF made by the Du Pont executives stressed the importance of management as a major input in technology transfer and assimilation:

> "During our visit [to HPF], I was struck by the terrible problems they had. We decided on the spot that we could give help to HPF without divulging any new or proprietary technology of Du Pont. There were no business risks for Du Pont in helping HPF, but there was a lot of goodwill to be gained.
>
> "I have made about eight trips in the past two years, and every time I returned to HPF, except the last time, they were in some kind of trouble. I would outline a programme for them to follow and when I am back in the USA, somehow after a couple of weeks, they would manage to get into trouble. ... Record keeping at the process level was unbelievably [poor] ... The manager in charge of the ____________ Department was a compulsive experimenter. He was an avid reader of technical journals and he used to experiment with all kinds of new formulations. It was a case of his working in the dark both figuratively and literally. ... Mr. ____________ could not believe that human errors were the cause of many bad emulsion batches. The emulsion area continued to be wasteful by excessive experimenting. Once Mr. ____________ was moved out of town there was a dramatic turn-around."

The view was expressed that in this industry, experience and applied knowledge were more critical than theoretical knowledge:

> "For example, they had problems with falling sticks in the coating plant and I knew from my experience, that all that was required was a change from a link chain to a roller chain. They were coating at 5 metres per minute and they had problems with static. They could not control humidity well. I had managed operations of this kind very early in my career and I knew instinctively that they can be set right. ... We spotted the problem with filters in base manufacturing. I had done this before. I could help them set it right."

HPF had originally approached Du Pont with the intention of setting up a plant for manufacturing polyester-based X-ray film. The Du Pont officials pointed out convincingly that technology developed in an advanced country with a large market might turn out to be economically unsuitable for a developing country with a much smaller market:

> "It was clear to me that if there was one thing that HPF did *not* need at this time, it was a full-fledged polyester plant facility with 200 million square feet capacity ...
>
> "We made it very clear to HPF that they did not need a polyester film base unit, which would cost at least $35 to 40 million, a level of investment and creation of capacity which can not be utilized fully for satisfying the demand within India. We are the world's leader in polyester-based X-rays. But for HPF, there was no need to chase technology without concern for costs. Even if we built a polyester plant in India, the cost of production would have been at least two to three times the comparative cost in the world's market. The Indian unit could not have exported polyester-based X-ray film with such a cost disadvantage. The reason for such disparity in cost is the small size of the plant in India that was supposed to supply raw material for the proposed polyester plant."

Attempts to find additional collaborators

As early as 1969/70, HPF thought of entering into additional collaboration agreements. It was realized that the technology of photographic manufacture was continuously being improved and that the gap between Indian techniques and those used abroad was widening. Through additional collaboration agreements, HPF hoped to expand and to enter into a long-term arrangement to ensure it would receive continuously updated technology.

In the early 1970s, the primary interest was in colour film under the influence of the cine industry. Concern for X-ray film was secondary. Teams for several companies, including Agfa-Gevaert, Kodak and ORWO, visited HPF and held discussions. First government officials and then HPF officials gradually became aware of the huge cost of a colour expansion programme. The investment required, estimated at Rs 200 million in 1970, had risen to Rs 500 million by 1973. The Government therefore withdrew its support for colour expansion and began to encourage production of X-ray film.

HPF carried on negotiations concurrently with several international manufacturers, with both positive and negative effects. One of the negative effects, in the opinion of a former HPF chairman, was that the company went around the world looking for other collaborators, giving Ferrania and 3-M the impression that HPF was not interested in their services. Instead, the company should have been making the best use of the specialists they had obtained as a result of the first collaboration agreement.

On the positive side, the fact that several potential sources of technology existed for HPF kept all the companies interested in the negotiations. Compared with the period 1956-1975, when Bauchet and Adox alone had shown an interest in negotiating with the Government, the post-1970 period showed considerable enthusiasm for negotiations on the part of all who were contacted. Of course, by then HPF was a going concern, whereas earlier it had been just an idea in the minds of a few persons. However, not all negotiations proved to be successful.

Kodak

Kodak showed considerable interest in setting up a joint venture with HPF. It indicated that, with an additional investment of Rs 220 million, excluding the cost of the film base department, a capacity of 15 million m^2 could be reached. It expressed an interest in participating in the additional capital. Once Kodak was informed that it would not be permitted to have equity in the current operations of HPF the company seemed to lose interest. When asked to submit fresh proposals for improving current operations, Kodak submitted a budget for a minimum of Rs 77 million and a maximum of Rs 94 million, including a technical fee of Rs 45 million. Even with this additional spending, it promised only a capacity of 5.6 million m^2 by the third year of operation. The HPF management considered the terms unreasonable, and the negotiations ended.

Agfa-Gevaert

In July 1973, the chairman of HPF visited the facilities of Agfa-Gevaert at Mortsel, Belgium, to explore the possibilities of entering into a collaboration agreement for a polyester plant. Agfa-Gevaert was prepared to sell its technical know-how on an outright basis. It meant that a possible collaboration with it would have been somewhat similar to the earlier collaboration with Bauchet. Nothing substantial came out of the negotiations except that HPF decided to import Agfa-Gevaert jumbo rolls for conversion purposes, a decision based on purely economic considerations. HPF purchased from whatever company offered the best terms.

ORWO

HPF had been importing jumbo rolls of cine colour film, X-ray film and roll film from ORWO. A licensing agreement was signed with ORWO on 9 July 1977 for the acquisition of technology to manufacture black-and-white negative roll film. For a licence fee of Rs 5.6 million, ORWO agreed to license HPF for the manufacture of its negative roll film (black-and-white). ORWO agreed to transfer the necessary formula and manufacturing instructions and to grant HPF the exclusive right to manufacture the licensed product in India. The agreement stipulated that:

(a) HPF could not use the brand name ORWO;

(b) The technology transfer was to be primarily in the form of technical documentation;

(c) The acceptance tests were based on a continuous and satisfactory production of 25,000 m^2 of the three varieties of roll film licensed (NP 15, 22 and 27);

(d) The acceptance tests were to be conducted in the ORWO plant at Wolfen.

The agreement seemed to be an improvement over the agreement HPF had had earlier with Bauchet for the same product in that six to seven HPF technicians were to be trained at the plant of the collaborator after they had studied the technical documentation, and the collaborator agreed to send six to seven of their specialists to assist in the production of roll film.

Du Pont

With Du Pont, HPF has signed or has been interested in signing several agreements. One particular feature of HPF dealings with Du Pont is that the two companies worked together for a few years without any formal agreement, during which time they established mutual trust and rapport.

For some time a distribution agreement was under negotiation whereby HPF was to be Du Pont's sole distributor of medical X-ray, industrial X-ray, graphic arts and industrial products. Once the Government insisted that HPF could not be made the sole distributor (in line with government legislation), the distribution agreement lost its meaning.

A process chemicals agreement was signed on 25 June 1976, whereby Du Pont agreed to transfer technical information necessary for producing and packaging the processing chemicals for medical X-ray film, industrial X-ray film and graphic arts. It also agreed to transfer technical information necessary for the design and construction of equipment to produce these products. The fee was a nominal one–$2,000 and 4% of net revenue for five years from the commencement of production.

A proposed agreement with Du Pont for a new finishing plant at Madras is a mere technical assistance agreement with the limited object of assistance in setting up a conversion plant. Hence, it cannot be compared with a turnkey type of agreement, involving transfer of know-how and supply of equipment. In such agreements, where the financial consideration involved is also high, the collaborator can be persuaded to accept responsibility for acceptance tests, quality guarantees, standard input-output relationship etc. In finishing plant agreements, where the financial consideration is not very high, the standard input-output relationship is related to the quality of the wide-stock rolls that are to be purchased by the company for conversion at the plant. The assistance of Du Pont will, therefore, be limited to installation of the plant, layout, establishment of operating procedures, go-no-go standards, commencement of production etc. While Du Pont will also assist HPF in selecting the equipment, the acceptance tests for such converting equipment will be demonstrated by the supplier of the equipment at his plant, with reference to the capacity of the machine.

Conclusions

A few tentative conclusions applying specifically to the HPF situation may be set forth.

1. In the early stages of setting up a new unit, technical considerations take precedence over economic considerations. However, once the unit comes under close public scrutiny, the emphasis shifts, with economic considerations predominating.

2. In an oligopolistic industry, dominated by a few giants from developed countries, small units from developing countries have little bargaining strength in negotiations.

3. In industries where the competitive edge comes from technology, research and development entail huge expenditure, which only a few can afford. This in turn perpetuates the oligopoly. Smaller firms can perform meaningful research and development only with the support of the Government.

4. Where applied technology is a closely guarded secret, held by a few, smaller units need to maintain a continuous relationship with the possessors of such technology. Little can be gained by studying patents unless one is an expert. In the photographic industry, technologists have to be trained internally.

5. Environmental conditions are a major factor affecting the technology absorption in the photographic industry. Close control over them through tight managerial systems is essential. What works in one environment need not work in another.

6. The problems of transferring technology to a new environment are difficult to solve through theory. They can be overcome either through trial and error, which is costly in terms of time and money, or with help from the experienced, which forces the new entrant to continue its technical dependence on the firms transferring technology.

7. A major index of technology absorption by a relatively small unit in a developing country is its success in import substitution. Here, the handicap arises not only from technological problems, but also from the poor economics of small volumes prevailing in such countries either for the outputs or the inputs.

8. Efficient management is an important requirement at all stages–search for technology, negotiations, installation of the project or its subsequent operations.

Annex I

SUMMARY OF THE COLLABORATION AGREEMENT WITH BAUCHET[a]

According to the agreement entered into between the Government of India and Bauchet of France on 25 April 1960 (and assigned to HPF on 5 April 1961), the collaborators were requred:

(a) To prepare a detailed project report for the plant;

(b) To deliver machinery and equipment for the plant from France and other countries;

(c) To supervise the erection of machinery and equipment and assist in constructing the plant,

(d) To provide consulting and technical services for establishing the plant and for subsequent production.

For providing the above services and supplies, a lump-sum payment of $6,081,632 (Rs 2.93 crores approximately) free of Indian taxes was to be made in 10 equal half-yearly instalments (with interest at 6.5% per annum) commencing 42 months after the coming into force of the agreement (i.e., 17 October 1960), the last instalment being payable after the enterprise had accepted the plant.

In addition, the collaborators were also to be paid 1.5% of the net value of sales turnover, or $80,000, $100,000 and $120,000 (in French currency) for the third, fourth and fifth years after the commencement of production, whichever was lower, for furnishing the following further services:

(a) After-sales service for a period of five years from the date of acceptance of the plant and machinery on completion of tests;

(b) Provision of mechanics and engineers to give technical advice on repair of defects and help in carrying out such repairs;

(c) Provision for five years after the commencement of production of specialists on maintenance of production and the removal of difficulties therein;

[a] *CPU Report* (April 1974), pp. 43-44.

(d) Transmission of the benefits of the technical development in their factory and laboratory as well as the facility for carrying out tests, experiment and research by mutual agreement.

The first three of these services were to be provided at the expense of HPF.

In addition, it was agreed in May 1969 that on the written request of HPF collaborators would send, at their expense, two competent technicians of different specialities for a maximum period of 30 continuous calendar days, excluding travel, in 1969, 1970 and 1971. The collaborators also agreed to supply any additional information on quality specifications and testing methods for the range of products covered by the basic agreement that might become available and the results of tests carried out from time to time at their consultant's plant (Ferrania at Savona) during the period of validity of article XIX of the basic agreement that are not of a confidential nature.

Annex II

MANUFACTURING PROCESS OF PHOTOGRAPHIC FILM

Photographic film manufacturing technology can be divided into the following major segments:

- Production of substrated cellulose triacetate
- Preparation of photo-sensitized emulsion
- Coating of sensitized emulsion on the film base (or baryta paper in the case of photographic papers)
- Converting the coated film or paper to the sizes required

In addition, silver-recovery-cum-silver-nitrate production forms an ancillary part of the process.

Film base

A flexible transparent sheet, the film base ranges in thickness from 0.090 mm for special-purpose film to 0.200 mm for sheet and X-ray film. It is produced by pouring a viscous solution called dope, which consists of cellulose triacetate dissolved in a mixture of solvents, on a continuously moving smooth surface (usually stainless steel) in the form of a large belt or wheel in an enclosed space. The film base is formed through a cooling process during which the solvents evaporate. Special coatings are applied to the base to give it various properties, including the ability to adhere to the emulsion coating, which is applied later. This process is known as substration. Substrated film base 450-650 m long and 1.2 m wide, known as jumbo rolls, is matured in a store-room before the emulsion is coated.

Emulsion

Prevailing photographic techniques are largely (though not exclusively) based on the light-sensitive properties of silver halide emulsions, especially silver bromides and, to a lesser extent, silver iodides and silver chlorides. The manufacture of photographic emulsions is a complex chemical process, considered to be the proprietary information of the firms in the business. As such, emulsion technology is a key area in photographic film manufacture. Light-sensitive emulsions are produced by precipitating silver halides on gelatin and then adding various chemicals to produce various properties (contrast, speed and fog) in the emulsions.

Coating

Coating consists of applying a layer of emulsion on the film base. Most film is coated on one side only, but X-ray film requires coatings on both sides. For producing colour film, multiple coatings are required on the same side. After coating, the emulsion is "set" by cooling, and the coated film is dried by controlled passage through regulated temperature and humidity. Coating technology requires precision to enable uniform layers of emulsion to be applied to large quantities of film base. Coated films, again in jumbo rolls, are then dispatched to the conversion or finishing department after a period in storage.

Conversion

In the conversion department, jumbo rolls are slit, cross-cut, perforated, wound or stacked and packed depending on the end-product desired–rolls of cine film, sheets of X-ray film and photographic paper, or spools of roll film for still cameras.

Besides the basic process of film manufacture described above, certain other characteristics are peculiar to this industry. One is the extraordinary emphasis on purity in working conditions and especially in the materials used to prepare emulsions. Absolute cleanliness is necessary at every stage of the process. This in turn calls for a considerable amount of inspection and quality control to minimize impurities in materials as well as defects in the finished products. However, with the exception of base casting and a few relatively minor processes, all other processes have to be performed in total darkness, or, at most, with safety lights, because the products are light-sensitive, which adds to the complexity of the whole technology. Finally, the reliance on silver halide technology calls for considerable economy in the use of silver, including its recovery from rejected and scrapped film. Recovery of film base and solvents used in base casting are also important processes.

V. Bharat Heavy Electricals Ltd., Tiruchirapalli: a case-study of transfer and absorption of technology

*Shishir K. Mukherjee**

Background

The Bharat Heavy Electricals Limited (BHEL), incorporated on 13 November 1964 as a new public-sector enterprise, was set up by the Government to take over the management of the following units, whose brief descriptions are given below, from the Heavy Electricals (India) Limited, Bhopal:[1]

> High-pressure boiler plant near Tiruchirapalli, Tamil Nadu
>
> Heavy electrical equipment plant near Hardwar, Uttar Pradesh
>
> Heavy power equipment plant at Ramachendrapuram, near Hyderabad

The new company began operations on 17 November 1964. The switch-gear and foundry forge units were added later to the Hyderabad and Hardwar units, respectively.

BHEL made rapid progress in manufacturing boilers and heavy power equipment such as turbo-generators and hydro-turbines, transformers and related equipment. It became one of the successful public-sector enterprises that not only helped import substitution in the rapidly growing power field, but also exported power equipment and diversified its production into other areas. The remaining unit of Heavy Electricals (India) at Bhopal was also integrated with BHEL in January 1974. Table 1 gives a summary of operating results of BHEL for the period 1966/67-1976/77. Table 2 gives comparative financial statistics for BHEL, Tiruchirapalli.

High-pressure boiler plant, Tiruchirapalli

The high-pressure boiler plant at Tiruchirapalli (Tiruchi) was set up in collaboration with Skoda-export, Czechoslovakia. It was designed for an annual output of 30,000 tons of finished boiler-house equipment corresponding to a power-generating capacity of 750 MW. The boiler-house equipment included the main steam-raising plant, economizers, air-preheaters, mechanical and electrostatic precipitators, fans, coal-pulverizing mills, high-pressure pipings, valves and other fittings. The value of annual output at full rated capacity was expected to be Rs 250 million. Construction of the plant began in 1963. The plant began regular production in early 1966 with the manufacture of valves and later of utility and industrial boilers. Production rose quite rapidly to the rated capacity, and the plant started earning profits from the third year of operations, even earlier than envisaged in the project report—a record achievement for a public-sector industry in India.

The present study of transfer and absorption of technology was mainly carried out at this plant, though an overview of the process of foreign collaboration and transfer of technology at the other plants of BHEL was also taken into account. All tables and annexes not otherwise specified refer to this plant.

Heavy electrical equipment plant, Hardwar

The heavy electrical equipment plant near Hardwar was set up in collaboration with Prommash-export, Union of Soviet Socialist Republics, with a capacity to manufacture nearly 1,500 MW of steam turbines and turbo-alternators, 1,200 MW of hydro-turbines and generators and 515 MW of large electrical motors and associated control equipment. The steam turbine sets were initially of 100-MW capacity each; later on sets of 200 MW were added. The value of annual output at full rated capacity was expected to be Rs 968 million. The unit began operations in January 1967, with the manufacture of flame-proof electric motors.

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[1] *Twenty-first Report on Bharat Heavy Electricals Ltd.*, CPU No. 204 (Committee on Public Undertakings, Fifth Lok Sabha, April 1972); Bharat Heavy Electricals Limited, Ministry of Industrial Development.

TABLE 1. SUMMARY OF OPERATING RESULTS FOR ALL BHEL UNITS, 1966/67-1978/79

(Millions of rupees)

Item	*1966/67*	*1967/68*	*1968/69*	*1969/70*	*1970/71*	*1971/72*	*1972/73*	*1973/74*	*1974/75*	*1975/76*	*1976/77*	*1977/78*	*1978/79*
Value of production accretion to stocks	238.5	431.9	693.0	704.8	779.6	1 051.4	1 414.0	2 309.3	3 119.8	4 214.0	4 709.7	5 539.2	6 591.8
Other income	9.9	10.5	8.0	11.3	16.3	18.0	30.7	44.0	61.6	67.9	102.7	139.5	237.0
Materials	149.7	268.8	436.6	378.6	388.3	537.2	744.6	1 280.0	1 515.4	2 277.5	2 471.7	2 817.2	3 501.5
Wages, salaries and other benefits to employees	87.9	105.6	125.9	155.2	178.6	196.1	246.1	345.2	532.7	602.2	627.4	745.6	850.5
Depreciation	55.8	59.2	57.0	59.2	68.9	75.5	80.5	84.4	89.7	108.0	129.4	172.7	205.6
Interest	37.7	73.9	93.2	114.3	116.8	118.1	109.7	127.4	224.6	311.8	327.0	268.8	288.3
Manufacturing and other expenses	42.7	50.6	81.3	101.3	94.6	105.7	131.3	242.4	309.5	435.8	627.4	1 100.2	1 477.2
Profit (loss) before tax	(125.6)	(113.7)	(92.1)	(92.5)	(51.3)	17.7	152.5	273.9	511.5	546.6	629.5	574.2	504.9
Cumulative profit (loss) after reserves	(403.6)	(518.3)	(602.1)	(723.7)	(775.6)	(736.4)	(589.3)	(561.7)	(194.0)	55.7	0.3	0.8	0.3
Equity	1 136.9	1 150.0	1 150.0	1 150.0	1 150.0	1 300.0	1 300.0	1 300.0	1 300.0	1 300.0	1 300.0	1 300.0	1 300.0
Borrowings and deferred credit	999.1	1 448.5	1 666.2	1 965.3	1 950.6	2 036.1	1 943.7	2 290.8	3 021.5	3 160.1	2 510.5	2 619.9	3 259.0
Reserves and surplus	0.1	0.1	0.1	0.5	0.5	0.5	0.6	198.1	301.5	357.9	561.1	742.8	920.9
Current assets	702.4	1 111.2	1 205.6	1 603.4	1 724.7	2 275.0	2 838.3	4 006.0	5 906.4	6 503.2	6 530.6	7 816.2	9 015.1
Current liabilities	351.2	643.0	838.0	1 045.2	1 222.1	1 481.7	1 956.0	2 426.6	3 157.9	3 543.7	4 343.2	5 737.5	6 445.0
Net fixed assets	1 298.8	1 520.3	1 667.5	1 740.1	1 754.3	1 757.5	1 729.2	1 667.6	1 661.7	1 844.5	2 184.0	2 583.9	2 909.8
Orders on hand (gross)	1 270.0	2 049.0	2 642.0	3 021.0	5 584.0	6 022.0	7 048.0	9 635.0	12 770.0	12 000.0	14 000.0	17 260.0	20 000.0
Number of employees	24 200	28 400	31 100	32 400	34 600	36 400	40 700	44 800	47 700	52 000	53 600	56 100	59 700

TABLE 2. BHEL, TIRUCHI: COMPARATIVE FINANCIAL STATISTICS

(Rupees in lakhs)

Item	*1969/70*	*1970/71*	*1971/72*	*1972/73*	*1973/74*	*1974/75*	*1975/76*	*1976/77*	*1977/78*	*1978/79*
Value of production	2 026	2 505	3 304	3 995	6 287	9 587	11 808	14 059	17 149	18 566
Cost of production	1 380	1 876	2 988	2 996	4 948	7 475	8 867	10 919	13 266	15 270
Interest	166	112	58	236	245	603	950	770	521	718
Development rebate reserve or investment allowance	283	44	7	6	36	66	5	104	38	64
Net profit (loss)	197	513	551	757	1 058	1 443	1 986	2 266	3 324	2 514
Current assets	2 634	2 948	3 959	5 781	9 277	13 449	16 066	18 251	23 645	25 155
Current liabilities	1 432	1 664	2 012	3 158	4 543	6 704	8 718	11 298	15 164	15 765
Working capital	1 202	1 284	1 947	2 623	4 734	6 745	7 348	6 953	8 481	9 390
Fixed assets (net)	1 785	1 761	1 751	1 736	1 998	2 312	3 087	3 437	3 574	3 844
Equity	1 159	1 122	1 474	1 434	1 434	1 434	1 434	1 434	1 434	1 434
Loan capital (from Government)	1 171	921	10	–	–	–	–	1 070	–	–
Borrowings	233	–	611	607	1 938	2 803	2 200	797	767	1 663
Depreciation reserve	510	602	698	731	841	1 193	1 357	1 564	1 840	2 092
Cash inflow	2 540	2 291	2 787	4 985	5 313	9 946	14 324	17 598	–	–
Loan repayments	1 084	287	559	50	–	–	–	–	–	–

Heavy power equipment plant, Hyderabad

The heavy power equipment plant near Hyderabad was set up in collaboration with Skodaexport to manufacture about 900 MW of steam turbines and generators up to unit sizes of 110-MW capacity, and associated auxiliaries such as boilers, food pumps, heaters, condensate pumps. The plant was also designed to manufacture radial and axial turbo-compressors with driving turbines for steel and chemical plants, small turbo-sets for industrial use, package plants and an extended range of industrial and power station auxiliary pumps. The value of annual output at full rated capacity was expected to be Rs 380 million. Construction of the plant began in 1963; the plant began operations in December 1965.

Acquisition of technology

The initial agreement for the high-pressure boiler plant

On 7 June 1961, BHEL signed an agreement with Technoexport of Czechoslovakia providing that Technoexport would prepare a project report concerning the setting up of a high-pressure boiler plant to supply matching boilers for turbo-sets being manufactured in the country at other plants. Originally the project report covered the annual manufacture of 12 boilers of 50-MW capacity each, along with accessories and 2,500 tons of valves. The detailed project report was completed in August 1962. Since it was felt that higher-capacity boilers of 60 MW and 100/110 MW would better meet the needs of the country, the project report was later modified to provide for a total production of 750 MW per annum consisting of 60-MW and 100/110-MW utility boilers and industrial boilers of 6-9 t/h capacity. The final project estimate of Rs 18.14 crores was approved by the Government of India in May 1963, but it was later modified to Rs 25.05 crores in 1971.

The initial decision to collaborate with Technoexport (later Skodaexport) in setting up the high-pressure boiler plant was taken by the Government of India as part of a broader technical collaboration agreement with the Government of Czechoslovakia. The project report was prepared by Technoexport and the plant and machinery were selected and commissioned by Skodaexport, with the help of Indian engineers.

Earlier, in 1955, when the Government was planning to set up Heavy Electricals (India) at Bhopal, it asked various well-known manufacturers of electrical power equipment to put forward proposals for assisting in providing design and manufacturing technology, supplying plant and machinery and training staff. Several foreign companies responded, but finally a British company was chosen. As in this case the basic strategy of the Government was to develop indigenous capability for manufacturing power equipment, the importers eventually became the collaborators. The collaborators provided the total plant and equipment as well as product design and manufacturing technology on a turnkey basis. Apparently this strategy was abandoned during the 1960s.

Following the success of the integrated steel plant at Bhilai, set up by the Soviet Union, the Government became interested in obtaining technical collaboration from the Soviet Union and Eastern European countries, especially in basic heavy industries.

At that time Czechoslovak industry was also known for its expertise in heavy engineering. India did not have much experience in the manufacture of boilers. Only one plant, namely, AVB-Vickers, was set up at Durgapur in the private sector with the collaboration and equity participation of Babcock & Wilcox, one of the major boiler manufacturers and suppliers to India.

Since the country envisaged rapid growth in power demand, the Government decided to set up the high-pressure boiler plant. It apparently decided to accept the Czechoslovak collaboration because it was part of a broader technical collaboration agreement, including the setting up of the Heavy Engineering Corporation at Ranchi; and it was based on rupee credit and involved no expenditure in foreign exchange.

Five companies joined together and acted as the collaborator under the name Technoexport. The project agreement with Technoexport provided for a lump-sum payment to the collaborator for supplying drawings and technical documents as well as determining design standards and principles for 60-MW and 110-MW boilers with the accessories and industrial high-pressure boilers. Separate payments were to be made for the detailed project report and for the plant and machinery purchased. The agreement also covered the training of almost 300 Indian engineers and technicians in the collaborator's design offices and plants.

The first group of young engineers, technicians and artisans sent for training at the collaborator's plants in Czechoslovakia remained initially for 2 to 2.5 years. Later on, for new trainees the period was reduced to 12-18 months. On their return these engineers and technicians worked as counterparts of Czechoslovak personnel in charge of various functions at the Tiruchi plant, of whom there were over 100, and from whom they were expected to take complete charge eventually. New graduate engineers were also selected for training by those returning from Czechoslovakia.

In accordance with the first contract to supply two boilers for the Ennore thermal power station near Madras, the design was carried out in Czechoslovakia, and BHEL trainees were associated with the design group. The specifications of materials were sent from there, and the materials were ordered in time. The plant and facilities were made ready when the trained men returned to Tiruchi and production started.

For these two boilers most of the pressure parts and piping, the burners, and the first set of mills were imported from Czechoslovakia, as were raw materials, plates and tubings, though some of these were obtained from the United Kingdom. Most of the sheet-metal fabrication and structurals were done at Tiruchi. Progressively, most of the components started to be manufactured at the Tiruchi plant. For different sections of the boiler, design groups were formed initially at the collaborator's plant in Czechoslovakia. Then when the trained engineers and technicians returned to India, similar groups were formed in Tiruchi. During the next three to four years, design and production technology was implemented with the help of Czechoslovak experts. Special attention was also paid to other functions such as inspection and quality control, so that the boilers manufactured in India met the designed quality standard.

Expansion and modernization of technology

As the production capacity of boilers in India was lagging behind the corresponding capacity for the production of turbo-generators and alternators, the first recommendation concerning the expansion of the Tiruchi plant was made by the Planning Group for Machining Industries set up by the Planning Commission for the fourth five-year plan in 1964/65. The company entered into an agreement with Skodaexport in January 1967, with the approval of the Government, for the supply of project documentation covering detailed capacity calculations and revised layout for the expansion of the high-pressure boiler plant from 750- to 2,000-MW capacity at a fee of Rs 14.58 lakhs. The project documentation was received in October 1967, and the fee was paid in November 1967 and January 1969.[2] At the same time, the Government of India wanted a study made on the feasibility of expanding boiler-making capacity in India. It asked Combustion Engineering, United States of America, one of the major boiler manufacturers in the world, to undertake a survey on setting up another boiler manufacturing plant (even after the proposed expansion of the Tiruchi plant). Representatives of Combustion Engineering visited the Tiruchi plant and later recommended that the Tiruchi plant be expanded in lieu of setting up an additional boiler manufacturing plant.

However, during the period 1966-1968 the country faced one of the worst recessions following years of drought, and the Tiruchi unit found itself in a difficult situation. It even considered diversifying its production to produce heavy equipment to keep its labour employed and capacity utilized. At that time it presumably also started considering entering the export market for boilers. A technical committee that studied the proposals for expansion concluded, in March 1969, that the revised outlook for power generation did not warrant the expansion of the Tiruchi plant from 750 to 2,000 MW, as the Czechoslovak project report envisaged, but only up to 1,200 MW. By this time BHEL had come to doubt the wisdom of expansion called for in the Czechoslovak report, and the scheme of expansion prepared by Skodaexport was not pursued further.

[2] *Ibid.*, p. 99.

In the meanwhile the technicians in charge of design of boilers had learned the Czechoslovak technology for boiler design and production. They began to see gaps between their designs and more modern boiler technology being discussed in the literature and implemented even at some boilers commissioned in India. Even before the Tiruchi plant was set up, a few boilers of modern design had been commissioned in India by Combustion Engineering and another firm in the United States. Accordingly, the design group of BHEL, Tiruchi, wanted to incorporate modern features in its design. The welded panel type of construction of boiler heating walls, where the boiler tubes are welded together with steel strips to form a solid panel, had come to be widely practised during this time. Combustion Engineering and some of the other manufacturers in the Western world were using this kind of construction. The design obtained from Skodaexport still consisted of bulky refractory walls, and the combustion chamber and the burners were less efficient. Similarly, the ball mills provided by the Czechoslovak collaborator for indirect firing of coal had an interbunker system, where ground coal had to be stored before firing. Since this system required more space and coal picks up moisture while being stored, it was considered much inferior to the direct firing systems with a ball mill being used by Combustion Engineering, which, along with Babcock & Wilcox, had the major share of the world boiler market at that time. The Czechoslovak design was also found to be much bulkier and heavier as compared with the more compact boiler designs being carried out elsewhere. It was also decided that BHEL should manufacture power plants of unit sizes of 200 MW and above needed by the growing power grids in India. The Czechoslovak designs were only for specific products of 60-MW and 100/110-MW capacity and could not be extended to higher capacities.

Accordingly, the Czechoslovak collaborators were asked whether they could provide such modern technology for boiler manufacture and design for high-pressure boilers of 200 MW and above. A top-level team of experts from Czechoslovakia came to India for discussions. It was agreed that they did not have the superior boiler technology that had been developed in the West during the 1960s. They also did not have designs for boilers for 200-MW and higher plant capacities at that time. They also suggested that BHEL examine the technology that had been developed in the West during the 1960s.

The Government and the Planning Commission set up several technical groups to study the expansion of indigenous boiler manufacturing capacity. The technical committee set up in January 1969 recommended that BHEL seek collaboration from Combustion Engineering, and subsequently negotiations were started with this company. Basically, it was decided that the power demand in the country did not justify a total expansion at that time, especially because the fourth five-year plan was not yet finalized, and capacity expansion in stages was recommended. On 30 November 1970, the Government of India gave permission to BHEL to sign the collaboration agreement with Combustion Engineering on the terms negotiated by the management, and the agreement was signed in March 1971.

The earlier agreement with Czechoslovakia was still legally in effect, but informally it ceased to exist when BHEL decided to change the design and, where appropriate, the manufacturing technology to conform to Combustion Engineering standards. The expansion of facilities corresponding to the agreement signed with Combustion Engineering was to be implemented in two stages. A third stage was added later.

Stage I

The expansion in stage I concerned reorienting the approach to design and construction at the BHEL, Tiruchi, plant and introducing new technology. The Combustion Engineering technology envisaged boilers with pressurized combustion chambers, welded-wall construction and a direct firing system with ball mills. During this stage an additional manufacturing capacity of 350 MW per annum was to be created, bringing the annual total capacity to 1,100 MW. The Government approved a project proposal for Rs 408 lakhs in March 1972. The additional facilities, including special-purpose Combustion Engineering machines for automatic welding of panels with boiler tubes imported from the United States, were completely set up in July 1974. With the commissioning of a 2,000-ton press for the boiler drum shop the project was completed in March 1975.

Stage II

A proposal to increase the annual manufacturing capacity of boiler-house equipment to 2,500 MW in view of the growing needs for power-generating capacity in the country was submitted to the Government. The cost was estimated at Rs 1,212 lakhs. The purpose of the project was to provide special-purpose and general-purpose machine tools, corresponding civil works, material handling facilities, services etc. necessary for increasing the output of the plant. Following the oil crisis of 1974, owing to the escalation of the prices of plant and machinery, the project cost estimate was revised to Rs 1,787 lakhs and the revised estimate was submitted to the Government in October 1975. The formal approval was obtained in March 1977 and the plant and machinery under the expansion scheme were installed. The stage II project was completed in March 1979.

Stage III

In view of the country's increasing need for power, a proposal for expanding the yearly capacity of the plant to 4,000 MW and introducing boilers of higher capacity (500 MW) was submitted to the Government for approval. It was approved in June 1979 and is now being implemented.

Entry into the export market

The decision to enter into a new collaboration agreement with one of the major boiler manufacturing companies was also precipitated by the performance of the company in the export market and the realization that the boiler plant needed up-to-date technology and boiler design to be able to compete. BHEL tried to enter the export market in 1970 by sending quotations against tenders. The first tender of BHEL for 30-MW boilers in Malaysia was rejected. After submission of a second tender BHEL was called to the United Kingdom for a tender evaluation meeting, where it was made clear that there were gaps in the boiler design and technology acquired by BHEL from Czechoslovakia and that BHEL was at least 8-10 years behind in the technology of boiler manufacturing. BHEL then learned some of these new techniques in a short time and supplied a boiler of 60-MW capacity incorporating the membrane-wall construction of the combustion chamber to Malaysia in 1970.

It can also be said that the decision of the management to enter the export market forced the company to update its technology, to improve its quality standards, to improve standards of preparing tenders and to deliver quality boilers on schedule. Whatever may have been behind the decision of the management to enter the export market–to earn foreign exchange to improve the balance-of-payments situation, to obtain much needed orders while the domestic market was suffering recession, or to provide a challenge to meet international competitive standards–it had a stimulating effect on the 6,000 BHEL employees. As a result, BHEL technology was updated and its design and delivery performance improved.

BHEL subsequently won several export orders from the Libyan Arab Jamahiriya and Malaysia, among others, backed up by the modern technology supplied by Combustion Engineering and other collaborators that has been adapted to suit the poor quality of Indian coal and conditions in a developing country.

Collaboration agreements for boiler-house auxiliaries

The decision to enter into collaboration with Combustion Engineering to manufacture high-capacity boilers also created a need to update the design know-how for boiler auxiliaries. The design of a boiler-house is usually custom-made to suit the conditions related to the capacity, the type of coal or other fuel used and the design pressure and temperature. Besides the basic boiler unit that generates steam from the combustion of the fuel, other units such as the coal pulverizer, air preheater, various kinds of fans, soot blowers and mechanical and electrostatic precipitators, feed-water pump and boiler-house equipment are other necessary auxiliaries, each of which has a specific function to perform. The boiler-house auxiliaries were earlier manufactured to the designs supplied by Skodaexport for the 60-MW and 100/110-MW units. To complete the modernization of the boiler plant, BHEL wanted to install high-capacity boilers and needed correspondingly better designed boiler auxiliaries.

Coal pulverizer (ball mill)

The coal pulverizer used in the Czechoslovak design, the ball mill type that provides an indirect firing system with storing of ground coal between the ball mill and the burners, was rather bulky, and various operating difficulties occurred. BHEL decided to install a direct firing system using ball mills designed and manufactured by a subsidiary of Combustion Engineering. It entered into collaboration with Combustion Engineering for the engineering and manufacture of ball mills for grinding coal at the same time it entered into collaboration for the boiler proper. However, grinding applications for materials other than coal are not covered under the agreement, and BHEL is permitted to manufacture ball mills of Combustion Engineering design only for use with Combustion Engineering boilers.

Air preheater

The first collaboration agreement after that with Combustion Engineering was signed with the United States Air Preheater Co., in May 1973, for the rotating-type Ljungstrom regenerative air preheaters, which are almost without exception in all high-pressure and high-capacity boilers throughout the world. The previous air preheaters manufactured by BHEL were of the tubular stationary type and were not suitable for high-capacity boilers. Air Preheater, one of the leading manufacturers of this equipment in the United States, has had considerable experience in designing and manufacturing this equipment. There are no restricting clauses in the agreement on the application of the air preheaters manufactured by BHEL. They can be used to meet requirements other than boiler-house application without infringing the collaboration agreement.

Axial and radial fans

Another collaboration agreement was signed in November 1973 with Kuhnle, Kopp & Kausch, Federal Republic of Germany, for reaction-type axial and radial fans. Although a small company, it was a well-known manufacturer of these fans and had a high growth rate; the BHEL management decided it was the best collaborator for the fans. The high peripheral speed, operational flexibility and the compact sizes of the reaction-type axial fans the company designed reduces the operating cost considerably. The collaboration is of a limited type. It does not cover basic design, but pre-engineering for fans is provided, on the basis of which BHEL designers can choose the suitable components. Pre-engineering work on fans is now part of BHEL research and development.

Electrostatic precipitators

BHEL was having various problems with the mechanical and electrostatic precipitators of Czechoslovak design it had been manufacturing earlier. Accordingly, it entered into a collaboration agreement with Svenskaflakt-Fabriken, Sweden, for electrostatic precipitators and conditioning towers, in November 1973. Svenskaflakt-Fabriken has been a leader in air-handling devices since 1918, and the company pioneered in the manufacture of these precipitators, which eliminate contamination from exhaust gases by mechanical electrostatic and chemical means. Since low-sulphur Indian coal makes the prediction of efficiency for electrostatic precipitators quite difficult, in-house research and development work has been started to establish better design parameters.

Soot blowers, high-pressure-low-pressure bypass system and valves

In April 1974, BHEL signed a collaboration agreement with Copes Vulcan, United States, for the manufacture of soot blowers. This agreement covered both electrical and air-operated long-retractable and half-retractable soot blowers, rotary soot blowers and automatic control systems. The agreement has a duration of eight years, is limited to four to five basic designs and involves payment of royalties. In 1976, BHEL also entered into collaboration with Sulzer Brothers, Switzerland, for the design and manufacture of high-pressure-low-pressure bypass systems, which are needed for high-capacity boilers along with related control equipment as a precautionary measure for outages and trippings of electrical generators. The agreement is for a period of five years and mainly for 220-MW systems. It involves a lump-sum payment, but no royalties, and limits the use of the system to use with boilers. Sulzer was selected on the basis of experience with its system.

BHEL signed still another collaboration agreement with Dresser Industries, United States, for the manufacture of sophisticated types of valves and oil field equipment.

Summary

BHEL is probably the only major boiler manufacturer that has acquired the capability for designing and manufacturing all the necessary boiler-house auxiliaries. Usually the major boiler manufacturers concentrate on the boiler and purchase auxiliary equipment from other manufacturers specializing in this equipment.

From the very beginning BHEL wanted to be self-reliant in this area. Its earlier collaboration with Czechoslovakia covered manufacture of boiler equipment, including all auxiliaries. However, when it decided to update its technology and entered into collaboration with Combustion Engineering it could not obtain the technology for the manufacture of the accessories from Combustion Engineering, since Combustion Engineering did not manufacture them at that time. Thus, BHEL had to enter into a series of collaboration agreements with various foreign companies to acquire the technology necessary for manufacturing these auxiliaries. (See annex I; note the seven-year gap between the first and second collaboration agreements.) Following the collaboration with Combustion Engineering, in almost all cases the BHEL management went through a process of evaluating manufacturers of equipment in various countries and selected the one considered to be the most forward looking and best manufacturer of boilers of higher capacity. This process of acquiring design know-how and manufacturing technology for high-pressure, high-capacity boilers and various auxiliaries should now be ended, since the collaboration agreements that BHEL has entered into cover a wide range of boiler designs and manufacture from 200 MW and above. However, this is a field in which technology is developing rapidly, especially in the design and manufacture of high-pressure boilers of 500 MW and above. Since BHEL has now decided to manufacture 500-MW boilers, an area totally new to the design engineers in India, BHEL may have to continue its collaboration with Combustion Engineering for several years after the current agreement expires in 1981 until it has mastered the design and manufacturing technology for high-capacity boilers and is also able to keep up with continuing developments in the field.

The collaboration with Combustion Engineering also covered the design and manufacture of various kinds of industrial boilers, including recovery boilers for the paper and pulp and chemical industries. The collaboration meant that all the knowledge and experience Combustion Engineering had gained in almost 100 years of designing and manufacturing boilers for various uses was available to BHEL–it could obtain the design and documentation, including drawings covered by any of the Combustion Engineering contracts covering coal-, oil- and gas-fired boilers for power utilities, as well as industrial and recovery boilers.

With the decision to design and manufacture 500-MW boilers, BHEL has entered a new era. A 500-MW unit has already been sanctioned for the Trombay power plant; other 500-MW units are expected to be commissioned in various thermal power stations in India. BHEL has still to master the technology for designing and manufacturing these boilers. It still has to gain experience, especially in dealing with the problems caused by the poor quality of Indian coal, which has a high ash content and is abrasive.

In recent years research and development in the area of combustion and boilers and related fields are being given a higher priority than before. BHEL has undertaken research on the problems of Indian coal and how the coal could be better utilized. It is carrying out design and pilot experiments with fluidized-bed boilers, a new and sophisticated field, and in other new areas such as coal gasification, magneto-hydrodynamic (MHD) power generation and research on solar energy. Thus, BHEL appears to have successfully absorbed the technology obtained through foreign collaboration and is now engaged in in-house research and development to make indigenous technology in new areas while keeping up with the most up-to-date technology in its main field of business.

The test of how successfully BHEL has absorbed the technology will be whether it can maintain the same standard as its collaborators and then go ahead with its own design in new areas unique to its own experience. It is perhaps too much to expect an industry to be able to absorb within the short span of about 15 years a foreign technology developed over 100 years or more and which is still moving ahead rapidly. But BHEL has been making good progress in this area. Although it may have to continue either extending its present collaboration agreement with Combustion Engineering and enter into new collaboration agreements during the next decade or so and even beyond that for specific equipment, it has started developing an indigenous technology that it can ultimately call its own. In this process BHEL has also succeeded in reducing imports of power equipment in India and is exporting such equipment to various parts of the world.

Absorption and adaptation of technology

The absorption and adaptation of technology can be described as a three-stage process after a foreign collaboration agreement has been entered into. Depending on the type of collaboration agreement and management decision, these three stages may start simultaneously, or they can follow in a sequence. During the first stage, the emphasis is on setting up plants and facilities and learning to manufacture the given product for which the collaborator supplies the complete set of drawings and manufacturing technology. Initially some of the components requiring complex production processes or proprietary technology may be imported from the collaborator, but the complete assembly is carried out at the local plant.

The second stage of technology absorption starts when the local firm learns to design either new products or carry out alterations in the basic product design supplied by the collaborator following the design know-how and principles supplied by the collaborator. During the final stage of technology absorption, the local firm generates its own design know-how and principles based on indigenous research and development in the product areas, as well as in the basic sciences or engineering applicable to the product.

For successful absorption of technology, perhaps all three stages should start right at the beginning of the collaboration, with highest priority initially given to the first phase. Since the manufacturing technology can be learned rapidly, more emphasis must be placed on learning design know-how through research and development: without progress in this area the process will remain incomplete and the local firm will remain dependent on the collaborators for the supply of product design and basic technology. In the case of BHEL, Tiruchi, an analysis shows that the first two stages of the process started almost simultaneously right from the beginning, since the management realized that boilers were very much of a custom-made product and that it was as important to acquire design know-how and principles as new manufacturing technology. During the collaboration with Skodaexport, design engineers as well as manufacturing engineers and technicians were sent for training. On their return to Tiruchi, while production of various boiler components and auxiliaries began, design and product development groups were also formed to design specific parts of the boiler.

The research and development effort at BHEL, Tiruchi, really started only a few years ago, following the preparation of a corporate plan and reorganization and rationalization of company-wide product profiles for the various manufacturing units. But the scope of the research and development was enlarged rather rapidly with the formation of an energy systems and new products division at New Delhi, a central organization for basic research and development at Hyderabad and unit-based centres.

Manufacturing technology

The manufacture of boilers involves capabilities of working with heavy plates and pipes in cutting, forming, bending and welding plates up to 96-mm thickness (for a 500-MW boiler's drum, up to 170-mm-thick plates are used) and high quality X-ray-sound welding. Capability of manipulating tubes and bending and welding them is also necessary. Manufacture of various boiler accessories requires sophisticated manufacturing technologies, including machining to close tolerances especially for nuclear components, heat treatment and complex welding processes such as submerged arc welding. Bending of pipes of various thickness and diameter is also a special technology for which special-purpose machines are used.

The collaboration with Combustion Engineering brought various new technologies to BHEL, including welding of a group of tubes with metal spacers to form membrane walls and bending such walls. Along with the manufacturing technologies came quality control and inspection requirements, production planning and other systems and procedures that had to be adapted to Indian conditions.

The plant went into production in 1966/67. The manufacturing technology was assimilated within three years following the first collaboration, when almost all the components planned for manufacture at Tiruchi were successfully produced. Production of items such as soot blowers, which the company had initially planned to import, was also undertaken. Imports of components from the collaborator's plants during the developmental period were at a lower level than originally planned.

Production increased during the initial years much faster than planned in the project report, and rated capacity was reached ahead of the seven-year target laid down earlier. Table 3 compares performance with targets. As a result of such accelerated growth of production in the initial years, the plant was able to reach the break-even point sooner and started earning profits from the third year of production. The project report envisaged only series production of two or three standard types of boiler, but owing to customer needs, the plant undertook to produce about 17 sizes and types of boiler even during the first phase.

From those early years, both the total production and product profits have grown tremendously, including utility boilers 30 MW-500 MW in capacity, industrial boilers and recovery boilers, various boiler auxiliaries, pressure vessels, equipment for nuclear power plants and oil-field equipment. The current product profile is given in annex II; the milestones of physical progress are given in annex III.

Annex IV shows the capital investment in the Tiruchi plant starting with the large initial investment. Annex V gives data on the manpower build-up at the plant over several years and a breakdown by category. Starting with 4,160 employees in 1966, the plant had a total work-force of over 12,000 in 1979.

In addition, BHEL has also received orders for steam-generating equipment, heat exchangers and other equipment for various nuclear projects in India, including the Madras atomic power project, fast-breeder test reactor and Narora atomic power project. This is a new area in which BHEL has learned the manufacturing technology, which requires working with stainless steel and other special materials to very accurate tolerances.

TABLE 3. PHYSICAL TARGET VERSUS PERFORMANCE

(Tons)

Year	*Target*	*Performance*
1966/67	2 190	3 230
1967/68	5 260	11 080
1968/69	11 700	15 220
1969/70	17 160	18 800
1970/71	22 000	21 950
1971/72	25 500	26 296
1972/73	30 000	53 810
1973/74	43 000	45 941
1974/75	59 200	59 600
1975/76	68 500	65 505
1976/77	67 350	. . .
1977/78	80 270	71 100
1979/80	90 580	90 602

Import substitution and export performance

The major objective of the Government of India in the early 1960s in setting up the high-pressure boiler plant at Tiruchi was import substitution in the rapidly growing need for power generation, transmission and other electrical equipment. The plant was meant to supply the domestic need for high-pressure utility and industrial boilers. Annex VI shows the foreign exchange saved from 1966/67 to 1976/77. This value is computed by expressing the total production of BHEL, Tiruchi, by its c.i.f. value and subtracting from it the total c.i.f. value of imported raw materials and components. For accurate computation, the total amount paid to collaborators as royalty and any other foreign exchange expenses (e.g., for travel abroad) should be subtracted. Nevertheless, annex VI shows the impressive record of BHEL, Tiruchi, in saving foreign exchange when compared with the total capital invested in plant and machinery.

Over the years, BHEL has also tried to use indigenous materials wherever possible. One of the necessary raw materials is seamless steel tubes that BHEL has not been able to obtain satisfactorily locally. BHEL, Tiruchi, is now setting up a seamless steel tube plant for manufacturing this basic material for the boiler plant, which will save foreign exchange. A reasonably large number of subcontracts of boiler-house products are now being produced using local materials. Use of local materials not only saves foreign exchange, but also reduces the price of the component.

In exports, the record of BHEL, which is still a reasonably young enterprise, is impressive, considering the stiff international competition it faces with many firms in developed countries. Since winning the first tender for supplying two 60-MW oil-fired boilers to Malaysia in 1969, BHEL, by June 1976, won 5 out of 16 tenders with a total value of Rs 4,248 lakhs. Data on BHEL imports and exports, for all units, showing expenditure in foreign currency for royalties, know-how, professional consultation fees, interest and other items are given in annex VII.

Assimilation of design know-how

BHEL from the very beginning of its Czechoslovak collaboration has given special emphasis to assimilating design know-how, an area in which it is difficult to measure achievement. In the long term, BHEL engineers may be able to design boilers based on the design principles and formula calculation provided by the collaborator; later they may create new designs to be tested in the field.

The Czechoslovak design was for some specific products of fixed capacity, boilers of 60 MW and 100-110 MW, and Indian engineers quickly learned how to follow their collaborator's design principles. The main process of assimilation was to convert Czechoslovak specifications (for materials) and standards to other standards so that raw materials of the required quality could be obtained from other countries and from local sources. During 1969/70 BHEL designed several boilers combining elements of design based on the Czechoslovak know-how obtained through collaboration and elements of the Combustion Engineering modern technology learned from literature and from boilers of this type supplied by Combustion Engineering at the Trombay and Chandrapura power stations. The BHEL management encouraged the designers to continue with this hybrid concept, and several boilers of 110-MW capacity designed using this approach are in operation now. This can be said to be a basic move towards indigenous development of boiler design capability. But, as BHEL did not have equipment for welded-wall construction and know-how for direct firing ball mills, it could not continue along this path for long. It would not, for example, have been possible to produce 200-MW boilers using this approach. The collaboration with Combustion Engineering opened a floodgate of design knowledge for BHEL designers. The collaboration was not limited to any particular size of boiler, but covered free and forced circulation boilers of 200-1,000-MW capacity. In addition, BHEL could ask for drawings and design calculations of any past contracts entered into by Combustion Engineering.

In addition to design know-how, Combustion Engineering also provided various systems that also helped in the production process at BHEL. One such system is the component-code system, which has improved the production planning and phased delivery of components to site. The assimilation process started when staff were sent to Combustion Engineering for short periods for training in specific areas. Their training reports have been widely disseminated among design engineers.

To obtain know-how and to raise questions that need to be clarified, a one-man contact has been established at Combustion Engineering. Since the beginning of the collaboration many technical queries have been referred to Combustion Engineering. The answers have been disseminated among the BHEL designers.

Semi-annual meetings are held in India at Tiruchi and in the United States to discuss various aspects of the collaboration. Combustion Engineering personnel also help BHEL to carry out a manufacturing and quality audit once a year, during which time various problems are sorted out. Changes in design are sent to Combustion Engineering for comments, and Combustion Engineering either agrees or disagrees with the proposed changes.

The design of the 500-MW boiler has opened a new area of assimilation of design know-how for BHEL engineers. At the same time, BHEL is learning from its experience in handling Indian coal, which may result in new design principles. In the area of the fluidized-bed boiler it is carrying out its own research and development. Thus the process of developing indigenous technology in the boiler field is continuing.

Research and development

It was recognized in BHEL that research and development in product design and product performance as well as in basic sciences and engineering are needed not only to absorb foreign technology and know-how, but also to take off from there to develop indigenous technology. The initial years at BHEL, Tiruchi, were spent in absorbing the design and manufacturing technology acquired through the collaboration with Skodaexport and subsequently with Combustion Engineering and the other firms mentioned earlier.

When the BHEL boilers were in operation and customer complaints started coming in, the company began field investigations of the boilers and their performance. However, it was realized that BHEL must branch into new areas of research and development, first, in testing the design parameters and underlying theoretical developments in the area of their products and then in basic areas such as power cycles, heat transfer, properties of materials, combustion of fuels and performance of systems composed of various units. It also recognized that since coal was India's basic indigenous energy resource, it had to engage in research and development on better utilization of coal for power generation and in other areas. BHEL also realized that it was not only concerned with manufacturing heavy electrical power equipment and heavy engineering goods, but was also concerned with energy systems. Thus, research and development in new energy systems such as solar energy, MHD power cycles, combined cycles and coal gasification processes and energy conservation were undertaken.

Research and development at BHEL can be classified as follows:

Conventional areas
New processes, products and systems
MHD generation systems
Welding
Solar energy

Much of the current research effort is concerned with major product lines--boilers and boiler-house auxiliaries--and with better utilization of Indian coal under the coal programme.[3] Research projects include combustion studies and burner development, erosion studies and a dust-separation programme.

Combustion studies and burner development

Combustion studies and burner development are carried out at two separate facilities for testing liquid and solid-fuel firing systems and equipment at the Tiruchi plant. Using these test facilities, flame and nozzle characteristics, flame stability, furnace heat transfer and pollution levels in the flue gases under different conditions of firing can be studied, e.g., with various types of coals, firing arrangements, designs of burners and coal-air mixing systems.

Erosion studies

A test rig has been especially designed and erected to study erosion by flue gases containing high concentration of ash and to develop abrasion-resistant materials and coatings for applications in a coal-fired boiler system. Studies are being conducted on the rate and pattern of erosion of different materials as a function of velocity used in the different parts of the boiler system. The studies include testing of samples of coal and ash collected at various power stations.

Dust-separation programme

Flue gases from a boiler contain dust and particulate matter that should be removed to reduce air pollution. Indian coal with low sulphur content creates problems for electrostatic precipitators, and their efficiencies are lower. A pilot plant for conducting studies with fly ash samples from several power plants has been constructed. These studies are expected to provide better design data for engineering, and thus more efficient and reliable electrostatic precipitators to handle Indian coal.

Fluidized-bed combustion programme

A 10-ton-per-hour prototype fluidized-bed boiler for industrial applications has been designed, manufactured and erected and is now being operated to test performance and collect data for testing design concepts and parameters. The fluidized-bed boiler [illegible] been tested under hot-water operation and ste[illegible] generating conditions. BHEL has also designed, manufactured and erected 2-ton-per-hour fluidized-bed boilers jointly with the Central Fuel Research Institute, Dhanbad, as well as with the Regional Research Laboratory, Jorhat. The first one is being utilized now in testing different types of coal to study their combustion characteristics under fluidized conditions. The other boiler at Jorhat will have an added feature for sulphur removal in the bed. BHEL has also designed a pressurized fluidized-bed combustion boiler of about 300 kg/h coal capacity. It is being installed at BHEL, Hardwar. The objective of the fluidized-bed boiler programme is to design and manufacture industrial fluidized combustion package boilers in the range of 10-15 t/h capacity. Various operational features such as lighting up, starting, load changing and shutting off of these boilers are being studied to make these boilers commercially feasible.

Development of new power cycles with coal gasification

Techno-economic studies of advanced power cycle concepts are being carried out to gain further knowledge of the design of hardware and systems, so that research and development projects, for the more promising cycles, can be started. A combined cycle demonstration plant of about 5 MW capacity is being installed at BHEL, Tiruchi, including a fixed-bed pressurized gasifier, a gas turbine of about 3-MW

[3] See H. N. Shram, *Research, Development and Demonstration and Commercialization Programmes for Better Utilization of Coal* (New Delhi, Bharat Heavy Elec icals Ltd., September 1977).

capacity, a waste-heat recovery boiler and a steam turbo-generator of 2 MW in a BHEL-patented new power cycle. Under the coal gasification programme, both in connection with the combined cycle demonstration plant as well as independently, various gasification processes suitable for Indian coal are being studied to identify the best process and establish engineering capability to design and manufacture commercial-size coal gasification plants. A project has also been undertaken to develop atmospheric producer gas systems for use in pulverized coal-fired boilers as substitutes for oils normally required for flame stabilization.

Magneto-hydrodynamic power system

BHEL has become involved in a co-ordinated research effort with the Bhabha Atomic Research Centre, Bombay, to develop MHD power generation systems. Initially, an MHD experimental plant of 5-15 MW capacity is to be developed with coal gas as the fuel for research and development to study optimum coal gasification systems for MHD power plants. The techno-economic feasibility of large MHD power plants will be studied based on scientific and design capability developed as a result of the experimental programme. The MHD research facility is being established at BHEL, Tiruchi.

Other activities

Research and development are under way on various aspects of solar energy and other new energy concepts. A central research and development centre for BHEL has been set up at Hyderabad to carry out basic research in addition to the research and development centres at each of the plants.

BHEL is also supporting research in some of the advanced engineering and technical institutions in the country. The central research and development centre has set up research facilities in metallurgy, material sciences, vacuum technology, applied mechanics, turbo machinery, fluid-control modules and special instrumentation, chemistry and corrosion, insulation technology and systems, electro-technical electronics, technology development and non-conventional energy sources.

As a result of its well-designed and well-co-ordinated research and development programme, BHEL is already benefiting from the development of new products and indigenous technology suitable for Indian coal, for example, the fluidized-bed boiler. Combustion Engineering and other collaborators have expressed interest in joining BHEL in a common research and development programme. BHEL is now spending about 2.5%-3% of its annual total sales on research and development, a reasonably high amount for an industry in a developing country.

Annex I

COLLABORATION AGREEMENTS

Year collaboration agreement signed	*Name of collaborator*	*Products covered*
1963/64	Skodaexport, Czechoslovakia	High-pressure utility boilers of 60 MW and 110 MW Industrial rollers of 6/9 t/h capacity, high-pressure valves
1971	Combustion Engineering Inc., United States	High-pressure utility boiler of capacity 200 MW and above Ball mills Packaged-type industrial boilers, waste-heat boiler Chemical recovery units
May 1973	Air Preheater Co., Inc., United States	Ljungstrom-type regenerative air preheater
November 1973	Aktiengesellschaft Kuhnle, Kopp & Kausch, Federal Republic of Germany	Reaction-type axial fans, radial fans
November 1973	AB Svenskaflakt-Fabriken, Sweden	Electrostatic precipitator and conditioning towers
April 1974	Copes Vulcan Inc., United States	Long retractable soot blowers, mill blowers and rotary soot blowers
January 1976	Sulzer Brothers Limited, Switzerland	High-pressure/low-pressure bypass system
January 1978	Dresser Industries Inc., United States	Safety valves, forged steel valves

Annex II

PRODUCT PROFILE

Boilers

Steam generators for utilities

Range: 50-500 MW

Fuel (or combination): coal, oil, natural gas

Steam generators for industrial applications

Range: 6-300 t/h of the following fuels:

Fuel (or combination): coal, oil, natural gas, industrial gases, bagasse

Waste-heat recovery plants of any size and for any gas

Recovery boilers for paper industry

Range: 100-1,000 t/d of dry solids

Boiler auxiliaries

Axial fans and radial fans of single or double suction for handling air or non-corrosive gases with dust loads of up to 100 mg/m^3 with pressure up to 1,500 m of gas column and delivery rate 4-1,200 m^3/s

Regenerative air preheaters for heating air or gas up to 350°C

Soot blowers: long retractable soot blowers (travel up to 13 m), wall blowers, rotary blowers and temperature probes

Slow and medium-speed coal pulverizers up to a capacity of 100 t/h

High- and medium-pressure valves; cast-iron and forged carbon steel valves of slide, globe, non-return (swing check and piston-lift check) type for steam, oil and gas duties up to 1,200 mm diameter and 400 kg/cm^2 pressure

High- and low-pressure bypass systems

Electrostatic precipitators of any capacity

Pressure vessels

Equipment for nuclear power plants

Steam generators of 236-MW capacity

Heat exchangers

Oil-field equipment

Full bore Christmas tree valves, well heads

Annex III

MILESTONES OF PHYSICAL PROGRESS

Project report begun	June 1961
Project report completed	August 1962
Project report approved by Government	May 1963
Construction begun	June 1963
Collaboration agreement with Skodaexport signed	June 1964
Partial production inaugurated	May 1965
First boiler components despatched	March 1967
First export order for valves received	February 1969
First export order for boiler received (2 x 60 MW)	January 1970
First BHEL-produced utility boiler commissioned (Ennore thermal power station 60 MW)	March 1970
First BHEL-produced industrial boiler commissioned (Manali 59 t/a)	August 1970
Collaboration agreement with Combustion Engineering signed	March 1970
First 120 MW export order received (3 x 120 MW)	June 1971
First nuclear steam generator order received (Kalpakkam)	May 1972
First 200-MW boiler drum manufactured	March 1973
Collaboration agreement with Air Preheater Company signed	May 1973
Manufacturing activities on nuclear steam generator started	October 1973
First BHEL-produced industrial boiler to Combustion Engineering design commissioned	November 1973
Collaboration agreement with Svenskaflakt-Fabriken signed (electrostatic precipitators and conditioning towers)	November 1973
Collaboration agreement with Kuhle, Kopp & Kausch signed (axial and radial fans)	November 1973
Collaboration agreement with Copes Vulcan signed (soot blowers)	April 1974
First electrostatic precipitator with Svenskaflakt-Fabriken technology manufactured and despatched to site	April 1974
First-phase expansion completed	July 1974
2,000-ton press commissioned	August 1975
Collaboration agreement with Sulzer Brothers, Switzerland	January 1976
First Combustion Engineering design 110-MW reheat boiler commissioned at Kothsgudem	March 1977
First prototype fluidized-bed boiler successfully tested	1977
Collaboration agreement with Dresser Industries, United States	January 1978
Order received for first 500-MW boiler	October 1978

Annex IV

CAPITAL INVESTMENT, 31 MARCH 1979

(Rupees in lakhs)

Original investment including workers' housing	2 448
Stage I expansion (1,100 MW)	444
Stage II expansion (2,500 MW)	1 766
Other schemes for auxiliaries etc.	580

Annex V

MANPOWER

(Number)

A. *Strength, 1966-1979*

Year	*Employees*	*Trainees*	*Total*
1966	4 160	...	4 160
1967	4 265	...	4 265
1968	5 266	100	5 366
1969	5 815	92	5 906
1970	6 263	125	6 388
1971	6 730	202	6 932
1972	7 147	174	7 321
1973	7 713	155	7 868
1974	8 410	144	8 554
1975	8 829	197	9 026
1976	9 494	328	9 822
1977	10 160	69	10 229
1978	10 943	80	11 023
1979	12 128	19	12 147

B. *Breakdown for 1975-1979*

	Year				
Category	*1975*	*1976*	*1977*	*1978*	*1979*
Executives	481	590	735	857	1 030
Supervisors	1 166	1 383	1 457	1 984	2 184
Artisans	3 597	3 834	4 014	4 363	4 929
Supporting technical staff	453	463	619	402	518
Unskilled workers	2 213	2 320	2 439	2 397	2 430
Clerical and other supporting staff	919	904	893	940	1 037
Trainees	197	328	69	80	19
Total	9 026	9 822	10 229	11 023	12 147

Annex VI

FOREIGN EXCHANGE SAVED, 1966/67-1976/77

(Rupees in lakhs)

Year	*C.i.f. value of production*	*C.i.f. value of imported raw materials and components*	*Net foreign exchange saved*
1966/67	293	117	176
1967/68	801	219	582
1968/69	1 156	197	959
1969/70	1 564	440	1 124
1970/71	1 932	479	1 453
1971/72	2 511	887	1 624
1972/73	3 163	1 376	1 787
1973/74	4 669	2 662	2 007
1974/75	7 174	3 174	4 000
1975/76	8 434	3 163	5 271
1976/77	9 516	2 527	6 989

Annex VII

BHEL IMPORTS AND EXPORTS, ALL UNITS, 1973/74-1976/77

(Rupees)

	Year			
Item	*1973/74*	*1974/75*	*1975/76*	*1976/77*
A. Value of imports (c.i.f. basis)				
Raw materials	189 510 868	499 142 030	651 410 271	321 567 415
Components and spare parts	449 744 780	377 405 261	436 925 288	694 493 583
Capital goods	15 202 837	13 170 835	48 675 282	94 420 143
Expenditure in foreign currency for royalty, know-how, professional consultation fees, interest etc.	31 281 784	52 982 286	57 530 981	130 182 119
B. Value of consumption of raw materials, components, stores, spare parts				
Imported		889 400 756 (59%)	1 400 158 534 (62%)	1 535 361 536 (62%)
Indigenous		625 211 213 (41%)	869 924 420 (38%)	936 316 838 (38%)
C. Earnings in foreign exchange				
Exports of goods (f.o.b. basis)	34 251 362	38 501 220	36 202 369	69 937 173
Interest and dividends	1 246 740	766 338	632 309	4 073 536
Erection charges recovered	3 993 661	4 296 852	5 685 534	4 259 311
Miscellaneous	27 504	18 170	1 272 090	326 265

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