R Working Paper No. 2/1967

ENGINEERING MANPOWER

EDUCATIONAL AND TRAINING PREPARATION OF TECHNICIANS

—A MEMORANDUM—

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FOREWORD

The Institute of Applied Manpower Research, in its work relating to engineering manpower, was concerned with manpower categories at various levels in the employment hierarchy. The problem of technicians in industry was discussed in several of its reports and in one of the seminars organised by it in June 1964.

2. The Institute's first area of detailed work in the "technician" field was to study the question of technician/engineer ratio to find out whether such an approach could be used in the projection of manpower requirements at technician level, which could in turn provide some guide lines for action by educational planners. This study was taken up in the Institute in September 1966 with the help of Mr. Robert S. Queener, Training Associate in Manpower, in the office of the Ford Foundation, New Delhi. The study could not escape the problem of terminology or definition of the terms "technician" and "engineer", on which the accuracy of the study largely depended. The lower end of the spectrum of engineering manpower, i.e., the skilled craftsmen and the skilled process worker and an amorphous group of "practicals" without formal education or training, also entered the picture to some extent.

3. However, the study revealed that the technician/engineer ratio in the Indian context possibly concealed qualitative deficiencies in either or both categories. It is with a view to locating these qualitative differences, if any, that the study was enlarged to cover the comparative methods and standards of technician education and training in India and other countries. This part of the study was undertaken by Shri K. R. Sivaramakrishnan, Chief of the Manpower Resources Division, in the Institute, who also carried the integrated study to an advanced stage.

4. What this integrated study tries to present is the concept of a "technician" as required by Indian industry at its present stage of development. It would be a mistake to import wholesale the concepts of technician education which exist in other countries and to set up on that basis training facilities for technicians with the help of industrially advanced countries. Neither the narrow specialisation of technician courses nor the pre-employment experience of the type as required elsewhere for seeking entry into such courses, can be relevant to Indian conditions. Our aim should be to evolve an Indian concept of technician education based on an understanding of the functions of a middle level technician as required in Indian industry. It is understood that a few projects with foreign aid are under way for the development of technician education. If through these projects,

or even due to lack of a clear concept of technician education in existing institutions, a variety of products are thrown up in the employment market based on the experience of the country providing the aid or the ideas of the Boards of Management of each institution or even the State Boards of Technical Education, then industry is most likely to be confused and a rational pattern of employment of technicians will not be generated. Industry would continue to prefer the graduate engineers due to the lack of consistency in quality and concepts in the products of polytechnic institutions. It is for this reason that a clear concept of "technician" education be developed now so that all technician education facilities, whether they are being newly developed or have been in existence for some time, are geared to this concept. This will help the generation of a rational pattern of employment structure in industry.

5. The interest expressed by Dr. T. Sen, Union Minister for Education, who desired an early discussion on this subject, provided a stimulus to expediting the completion of the integrated study and submission of this paper.

6. The experience of, and problems faced by, industry were discussed extensively with Prof. A.S. Sen of Guest Keen Williams and Indian Engineering Association, and the Institute is grateful for his assistance in the formulation of the recommendations.

7. It is hoped that the report will generate the discussion necessary to bringing this problem to the fore and finding an early set of solutions.

P.K. DAS
Director

19.6.67

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CHAPTER I

CONCLUSIONS AND RECOMMENDATIONS

SUMMARY OF CONCLUSIONS

Objectives of the Memorandum:

1. This Memorandum attempts to:

   (a) study the place of the middle level technician in industry,

   (b) study the current pattern of technician education and training of diploma holders in engineering and technology, and

   (c) suggest a solution to the problem of qualitative matching of educational and training programmes for the middle level technicians with the requirements of industry.

The Problem:

2. In the Institute's study relating to engineering manpower, the question of engineering personnel just below the level of graduate or professional engineer has been discussed several times. In the "Seminar on Collaboration between Industry and Technical Institutions" held at Madras in June 1964, where polytechnic education and technician positions in industry were discussed in great detail, there was general agreement that the present courses were inadequate in so far as practical training is concerned. A special study undertaken by an officer of the IAMR in 1965 in countries of Western Europe, USA and Japan, on "Significant World Trends in Engineering Manpower Development", recommended the development of functional programmes at technician level in consultation with employing industries with a view to gradually replacing existing general engineering courses at the diploma level.

3. The need to effect a drastic change in the existing system of polytechnic education has been recognised by bodies such as the All India Council for Technical Education as well as by the Education Commission. The All India Council for Technical Education as early as in 1961, had come to the view that "a stage had been reached at which the entire question of the aims and objects of diploma courses,

their contents, standards of training and other aspects should be reconsidered in relation to the changing pattern of employment of technical personnel in industry and other sectors".* Recently, the Education Commission has referred to "the present weaknesses of the diploma training being insufficiently practical or industry-oriented" and recommended "immediate steps to carry out investigations in cooperation with industry aiming at job analysis and specifications in terms of levels and clusters of skills and responsibilities for technicians"** so that the diploma courses would be revised aiming not at producing a lower class engineer but a technician in real terms.

4. This problem is not peculiar to Indian conditions. A White Paper† of the Government of the United Kingdom presented to Parliament in January 1961 stated that the needs of the technician cannot be satisfactorily met by courses which are primarily designed for craftsmen on one hand or technologists on the other. There must be courses specifically adopted to his requirements and coordinated with his industrial training. Similar problems in respect of the education and training preparation of the technician for industry have been faced in other countries in Europe as well as in USA.

5. The lack of adequate and distinct educational preparation for the technician required by industry has had its repercussions on the employment pattern in the industry. In a number of industrial establishments, craftsmen have risen to technician positions over a period of years; but because of the inadequacy of their educational preparation, they have not been as effective as they should be to meet the challenge that the technician post normally calls for. Alternatively, the graduate engineer or professional engineer is placed in technician positions though he is neither meant nor prepared for these tasks. This underutilisation of an engineer results in frustration and lack of job satisfaction. In both cases, quite

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* Proceedings of the 14th meeting of the All India Council for Technical Education, held on July 7, 1961, Govt. of India, Ministry of Education, Para 32.

** Report of the Education Commission, 1964-66, Govt. of India, Ministry of Education, paras 15.21 - 15.23.

† "Better Opportunities in Technical Education", Cmnd 1254, HMSO, London, page 5.

often the actual functions of the technician remain unfulfilled. The Estimates Committee* and various Committees of Parliament in examining the employment structure in public undertakings have commented on the low level of utilisation of a number of graduate engineers on subordinate supervisory jobs, in public undertakings. The Education Commission has referred to this as "a wasteful use" of the skills of the engineers and "an unnecessary charge" on training costs. The lack of adequate preparation of technicians for employment in industry therefore results in higher investment in engineering colleges because of the higher rate of employment of professional engineers in technician positions. Further, it results in lack of specialisation in the technician function. This is an essential part of the technician job requirement and its inadequacy results in lower performance in the undertaking. In a number of cases, it also results in faster promotion of worker level personnel without adequate knowledge resulting in dilution in the quality of personnel required at the technician level. A vicious circle has thus developed where the educational system is not geared to produce sufficient number of technicians of the right calibre and quality for the employment market, and the employment structure in many industries has no specific place for the technician. All these problems are being faced by Indian industry and the sooner a set of solutions is found the better it would be for industrial development.

Who is a Technician:

6. As will be seen from Chapter II, where an attempt has been made to discuss the various definitions which are used in different countries and industries to identify the type of tasks and responsibilities shouldered by the technician, there is no single universally accepted description of the role of the middle level technician in industry. While the definitions described and discussed in Chapter II provide a detailed picture, the following general conclusions may be drawn from these definitions about the role, place and educational preparation of the technician:

(a) In a job hierarchy the technician's role falls between that of the skilled worker and the professional engineer (or technologist).

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* Report of the Estimates Committee (1963-64), Govt. of India, page 48.

(b) A technician is required to have adequate scientific and technological knowledge in a relatively narrower speciality compared to a professional engineer and at the same time have technical knowledge and skills in a broader number of trades or activities than those required of a skilled worker.

(c) His position requires that by virtue of his education he should understand the details of technical "know-how" laid down by the professional engineer and communicate the same as technical "do-how" to the skilled worker or use it in his work if he has to accomplish the tasks himself.

(d) His knowledge of science and technology must be such that it would be capable of adaptation for future advances in science and technology in that speciality.

(e) His educational and training preparation should enable him to have knowledge in a specified speciality of technology, acquaintance with a variety of manual skills required by workers in that branch of technology, and supervisory knowledge and skills.

(f) Finally, he is basically an "application-engineer" and not a development and research engineer and applies specific proven techniques associated with science and technology, though he might also be useful in research and development or design organisations to work under the guidance of professional engineers/technologists.

Employment Pattern:

7. Since the technician in terms of his status in an employment pyramid is between the skilled worker and the professional engineer/technologist, the total number of technicians required in any branch of activity would obviously fall somewhere between the numbers of skilled workers and the numbers of professional engineers or technologists.

8. The discussions in Chapter II indicate that there exists a major difficulty in obtaining and comparing employment patterns of the middle level technician in industry because of the variations in definitions and utilisation patterns. The overall ratios of employment of professional

engineer and technician which have been most frequently mentioned as desirable ratios vary between 1:2 to 1:5. It is also likely that in some industrial activities, the engineer to technician ratio may be in the reverse proportion. The Education Commission has recommended a target of an overall ratio of engineers to technicians of 1:2.5 by 1975 and 1:3 or 1:4 by 1986.

9. It would seem to be a risky proposition to accept any of these ratios as applicable to the whole of the economy or even to different sectors of industries or technology because more detailed studies indicate that the ratio of technician to an engineer is a derived index of engineering employment in a country under existing conditions and pattern of industrial production and other forms of industrial activity, as well as on several other factors including the type and quality of technician and graduate engineering education. The ratio also depends on the manner in which the technician specialities are grouped, the level of industrial development of the country, and the stage of scientific development of the subject matter.

Educational Pattern:

10. As discussed in Chapter III, the pattern of educational preparation of the technician in India seems to be in a state of flux. There are three patterns in existence, viz. —the 3 yrs. diploma course, the 2 yrs. technicians course and the sandwich course. Out of this, the 3 yrs. course is most extensive being offered in 259 polytechnics with a total admission capacity of 47,000 per year and an annual outturn of 17,000 in 1965, which is expected to be doubled by 1975-76. The 2 yrs. technicians course is more specialised and is offered in 8 polytechnics— with an annual outturn of 660 in 1965, which is likely to increase to 1,200 in 1975. The two sandwich courses are offered in 9 centres (6 mechanical, 3 chemical) with an annual admission capacity of 400 students (280 mechanical, 120 chemical).

11. The 3 yrs. and 2 yrs. courses are almost wholly institution based and generally academic and theoretical in content. Though a 2 yrs period of practical training in industry on completion of the institutional course is envisaged, in actual practice, since this training is neither planned, supervised nor controlled, most students do not go through it.

12. The facilities developed so far would give an out-turn of 35,730 technicians annually by 1975-76 as against 24,000 graduate engineers,

which gives a ratio of degree to diploma outturn of about 1:1.5.

13. Some of the major weaknesses of the existing pattern of diploma education are:

(a) Insufficient specialisation,

(b) Inadequate or almost no practical training other than the workshop practice or laboratory work included in the institutional course.

(c) Wherever the course is either of 2 yrs duration or heavily practical as in the case of the sandwich pattern (46 weeks institutional and 136 weeks practical), the technician is not prepared adequately for the 'theoretical' content of his job.

(d) Lack of involvement of industry in the design of the programme of pre-employment preparation of technicians and in its actual implementation.

14. Mention may also be made here of courses meant mostly for the development of technician level personnel organised by some large industrial undertakings particularly in specialities where technician courses have not developed adequately in polytechnics. The steel industry in particular, both in the public and private sectors, offer such courses for technicians in ferrous metallurgy by recruiting graduates in general science and training them over a period of 18 months to 3 years.

15. Looking at the educational pattern for technicians in industrially advanced countries, it would be found that there is no single pattern. It varies between wholly institution-based pattern and wholly industry-based pattern; from one type of diploma or certificate to two or more types; from wholly institutional courses to sandwich pattern of courses. But in all the patterns, there is consistency in respect of the following:

(a) the technician courses are narrower in speciality compared to the professional engineer/technologist courses;

(b) a balance between theory and practice is ingrained in the course either through a sandwich type of curricular pattern or by insisting on pre-participation industrial experience of 2-3 years duration.

(c) a balance in terms of time and subject allocation to technology (theory), practice (training) and humanities (supervision and administration, etc).

RECOMMENDATIONS

General:

16. To solve these problems, it is recommended that urgent steps be taken broadly in the following directions:

(a) Narrowing the major branches of engineering or technology into technician specialities for the pre-employment preparation of technicians.

(b) An overall normative approach to the development of facilities for technicians courses would be undesirable and impracticable. Therefore more detailed consultation with industry should be held for determining the volume of facilities required in each speciality and this can be done only after the specialities have been grouped.

(c) Improvement of the standards of educational preparation of technicians by:

(i) raising the minimum qualification for admission to technician courses to a pass in the Higher Secondary examination or its equivalent.

(ii) standardising the length of course—3 years (+ 1 year terminal training). Also introducing sandwich pattern of education and training within the 3 years.

(iii) improving the content of syllabus of the programme,

(iv) improving the calibre of teaching staff and facilities in polytechnics.

(d) Improvement of the standards of training by making more firm arrangements with industry, preferably by making the participants largely industry based and through more systematic supervision from the educational institutions. This would also require that polytechnics be located in the vicinity of those industries they serve.

(e) Giving a status to the technician courses so as to divert the heavy bias which exists among school-leavers for degree courses in engineering and technology.

(f) Similarly, giving consideration to the question of which type of institutions can offer these courses best, and what should be the identifying title given to these institutions.

17. The specific steps to be taken in these directions are discussed in the succeeding sections.

Speciality Grouping:

18. The study indicates that it is absolutely necessary to develop courses for technicians on narrower specialities than the broad branches of engineering/technology offered in degree level institutions. But it would not be desirable to transfer enbloc the speciality groupings for technician courses as they exist in any given industrially advanced country. As mentioned earlier, this grouping largely depends on various factors which are peculiar to the country or industry concerned. Moreover, because of our short industrial history, we cannot afford to create too narrow specialisations in technician courses which will result in problems of mobility for narrowly trained technicians.

19. It is therefore suggested that small Working Groups consisting of representatives of industry and educational institutions be constituted as soon as possible in the following major branches of engineering and technology, which will determine the manner of grouping of the technician specialities for their educational development:

(a) mechanical engineering
(b) civil engineering
(c) electrical engineering
(d) chemical and matallurgical engineering

Each of these would obviously cover more than one industry and therefore the Working Groups should have representatives from atleast the major industries concerned. Alternatively, these Groups could be set up with reference to major branches of industry, such as Fertilizers, Petroleum, Iron and Steel, Machine-tools, Textile, Electrical Machines and Power, etc., each Group, accordingly, covering more than one speciality of technician study. When these Working Groups complete their work, more Working Groups in other major branches may be added, such as in

(a) Agriculture
(b) Mining
(c) Medicine and Public Health
(d) Other services

20. The main work of these Working Groups would be to identify the technician specialities for educational development, keeping in view:

(a) the stage of development of the major branch of engineering or technology and of the speciality in question.

(b) the need for specialised services in industry at the technician level on the one hand and the need to avoid problems of mobility if too narrow specialisation is attempted, considering the stage of development of Indian industry.

(c) the fact that the entry qualification for the course will be Higher Secondary pass, and the course will be of 3 years' duration, plus 1-year terminal training.

21. The issues to be considered by these Working Groups may be illustrated in the following examples:

Example 1

Within the broad branch of mechanical engineering there are a number of trades at one end as shown below:

Engineering Trades	Technician Speciality	Engineering Branch
Fitters Welders Turners Machinists Pattern Makers Moulders	(1) Machine shop technician (2) Foundry technician	Mechanical Engineer

It may be seen from the above, the technician who may be required to supervise workers in the above mentioned engineering trades, and translate the advice and instructions of the professional engineer may either be trained as a "machine shop technician" <u>or</u> as a "foundry technician" <u>or</u> as a "machine shop-cum-foundry technician". The Working Group will take into consideration the points mentioned in paragraph 20. above and recommended appropriate technician speciality or specialities to be developed.

<u>Example 2</u>.

In a metallurgical process industry where the skilled worker positions are filled by employees qualified not in the engineering trades, but in operational knowledge and skills, the major branch of engineering is "Metallurgical Engineering" as shown below.

<u>Operative Occupations</u>	<u>Technicians Specialities</u>	<u>Branch of Engineering</u>
Blower Operator	<u>EITHER</u>	
Skip Operator	Ferrous Metallurgy Technician	Metallurgical Engineering
Cast House Man		
O. H. Furnace Man	Non-Ferrous Metallurgy Technician	
	<u>OR</u>	
Rolling Mill Operator	Extractive Metallurgy Technician	
Reheating Furnace Operator, etc.	Rolling and Shaping Metallurgy Technician	
	Heating and Treatment Metallurgy Technician	
	<u>OR</u>	
	Blast Furnace Technician	
	Melting Shop Technician	
	Rolling Mill Technician.	

In the above branch of engineering/technology, it may be seen that there are atleast three ways in which the technician specialities can be arranged. It would be up to the Working Group to determine which of the three (or other) alternatives would be preferable.

Example 3

Similarly within the branch of Civil Engineering, the technician specialities may be determined as indicated below:

Trades	Technician Speciality	Branch of Engineering
Brick Layer	Building Construction Technician	
Reinforcement binders	Roads and Highways construction Technician	Civil Engineering
	Bridges and Dams Construction Technician	
Carpenter	Hydraulics Technician	
Painters	OR	
Plumbers	Construction Machinery Technician	
	Reinforcement and Shuttering Technician	
	Concrete Technician	
	Water Proofing Technicians, etc.	

22. It would also seem necessary that these speciality groupings be reviewed periodically, preferably every five years to determine whether a need has arisen to develop narrower specialisation and/or for revising standards. In addition, it would be necessary to assign to a suitable agency the task of locating the emergence of new specialities at the all-India (Govt. of India) level, and to examine the development plans of both the public and private sectors, with a view to advising the concerned authorities on the need for developing training facilities in new technician specialities or on enlarging or reducing facilities for existing specialities. It might also be necessary to set up permanent advisory bodies in these major branches of engineering/technology, similar to the Trade Committees set up for the implementation of the Apprenticeship Act, 1961, who will discuss these problems and suggest solutions.

Volume of Facilities:

23. As discussed earlier a simple overall engineer/technician ratio for the development of technician education/training facilities would be undesirable. This ratio will vary from industry to industry and on how the technician specialities are grouped. It may also vary over a period of time.

24. It is therefore recommended that each one of the Working Groups mentioned above also goes into the question of the criteria for assessment and volume of demand for technician training facilities in each speciality. For example, it would be fairly easy for the Metallurgy Group to say what would be the ratios of Blast Furnace Technicians to Steel Melting Technicians to Rolling Mill Technicians, in a total group of technicians for the Ferrous Metallurgy Industry. The same would apply to the Civil and other engineering branches.

25. Under the system of industry-education link being proposed in this memorandum (para 47) the possibility of over-production of technicians will be minimised.

Admission Qualifications:

26. At present, the minimum qualification for admission to the diploma courses in engineering is Matriculation or equivalent and for the 2-year technician course, it is Higher Secondary pass or equivalent. It is seen that the admission requirement for degree courses in engineering is a pass in Higher Secondary or equivalent, and for apprenticeship in various trades under the Apprenticeship Act the minimum requirement varies between Matriculation pass and two class below Matriculation depending on the trade. The question to be considered is whether the admission qualifications for technician courses should be nearer to those required for trade courses or those required for degree courses. The type of manual skilled workers required by industry are to come from the Apprenticeship programmes and industry-based operatives' training programmes. Some of these personnel, after years of experience and special employee-development programmes will grow to higher positions which may be at the "technician" levels. The development process may be assisted by the offer of "off-duty-hour" courses. But industry also requires persons who have a sound knowledge of the fundamentals of engineering or technology, who can organise and plan the work of skilled workers, and supervise their work. Also, industry requires technicians who can assist professional engineers or technologists in design, development and planning activities by taking over some of their simpler activities and performing them under their general guidance, with knowledge and understanding higher than those possessed by a draughtsman, tracer or skilled worker. Both these types of technicians require an educa-

tional preparation which is closer, in content and standards, to the degree courses. There has been a tendency throughout the world, as discussed in Chapter III, to give the technician a sound knowledge of fundamentals along with greater stress on practical work. Moreover, technologies involved in technician specialities are always in a state of transition, and unless a sound development of fundamentals is attempted in the technician education/training programmes, problems of adaptation to changing technology will arise during the working life of such personnel. Keeping these trends and requirements in view, it is proposed that the minimum admission qualification for the technician courses be laid down as a pass in Higher Secondary examination or its equivalent.

27. The Education Commission has recommended a ten-year pattern of schooling succeeded by a period of 2-years Higher Secondary education for the whole of India without any attempt to introduce specialisation during the first 10 years. This recommendation is at present under study in the Ministry of Education and by the State Governments and future structuring of technician courses—as also of professional degree courses in engineering and technology—will depend upon the decision taken on this recommendation. In case it is decided to introduce the 2-year Higher Secondary course, then the question arises whether to channel out the school-outturn after the 10 years into technician courses and impart the higher content of science, mathematics and applied science as a part of a long technician course, or to carry the school-outturn through a 2-year Higher Secondary education after which they may be channelled into the technician courses. It seems, that the 2-year Higher Secondary schooling will have atleast three streams, and provided the "technical" stream curriculum is properly designed, it would be preferable to draw students for the technician courses from the outturn of Higher Secondary schools. This will have some major advantages. A larger number of students completing 10 years of schooling can take terminal type courses in a variety of vocational and commercial trades. But for higher education, it would be preferable from the manpower angle, that the point of diversion from the general educational stream to specialised professional education is extended upwards or postponed thereby, inter alia, reducing the period of specialised educational preparation; this would facilitate a closer coordination between the outturn and the demands of the labour market as also make available the advantages of more precise manpower projections for a shorter period. Secondly, the continuation of the student-body through the 2-year Higher Secondary schooling would enable them to exercise a choice between the technological education channels depending on their attainments and vocational preferences that develop during this 2-year period, rather than be limited to a choice of the technician specialities only. This is quite important as this is the first

stage where the student is exercising a choice regarding the field of his higher education. Figure 1 gives the channelling process after the 10-year schooling as envisaged in this Memorandum.

28. A comment seems necessary regarding the specialisation process at the Higher Secondary stage. The 10-year school-outturn goes either into terminal types of courses or into higher education. The 2-year Higher Secondary courses are therefore not terminal in character. It is understood that the States which have introduced "technical education" at the Secondary stage, are facing difficulties in regard to the absorption of the outturn in industry. This problem will exist if these courses are treated to be terminal in character because the needs of industry at this level of educational preparation are quite different. The existing courses neither aimed at development of manual skill required of a craftsman nor provided the broad development of technical knowledge required of a technician. The 2-year Higher Secondary courses must therefore be treated as non-terminal courses.

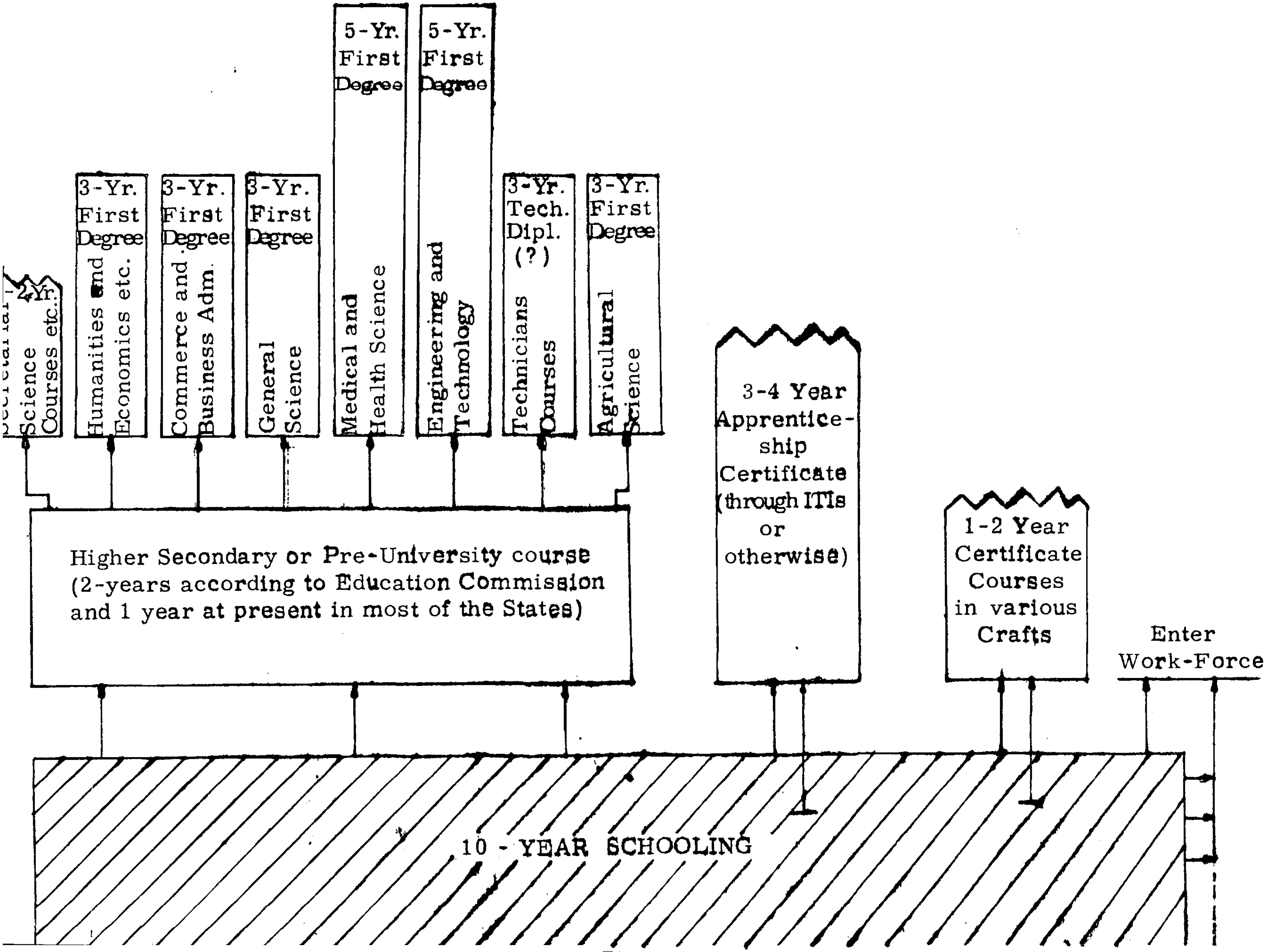
29. If this is accepted, then it is suggested that too many streams be not introduced at the Higher Secondary stage. The subjects of study may be grouped in such a way as to provide three major streams as follows:

(a) General Group
(b) Science Group
(c) Technical Group.

Moreover, just as choice of one elective subject decides the Science Group's channelling into the higher education stream (biology for medical education, physics or chemistry for engineering education, etc.), similarly choice of one elective subject in the Technical Group should determine the further channelling (workshop practice for degree and technician courses in engineering, cultivation and horticulture for degree and technician courses in agriculture, etc.). This leads to the advantage of narrowing down the choice considerably compared with as many as seven streams now offered in certain states so much so that Higher Secondary courses could also become part of institutions of higher or technician education.

30. The General Group would have the normal subjects in the humanities and commerce groups. The Science Group would have the normal general science subjects and mathematics. The Technical Group would also have general science and mathematics subjects, but there would be an element of manual work and introduction to applied science, engineering and technology. The outturn of the "technical" stream could go in for degree engineering/technological courses provided they have attained a certain minimum proficiency in selected subjects, such as in mathematics and science for engineering degree courses.

FIG. 1: FLOW-CHART FROM 10-YEAR SCHOOLING UPWARDS



31. While suggesting that the entry qualifications for technician courses be Higher Secondary examination pass or equivalent (irrespective of whether it is going to be a 2-year period or less), it is to be remembered that the same qualifications apply to entrance into colleges of engineering and medicine, etc., for degree courses. The only distinction that is proposed to be made is that there should be no criteria for admission into technician courses which specifies a minimum "division" or "grade" in the higher secondary examination. In its place, it is recommended that a functional test by introduced as a qualifying test for entry into technician courses. This functional test should be specifically developed and tested over a period of time regarding its correlation with technician performance.

32. Whereas the pre-employment preparation of a technician through technician courses recommended in this document is meant for those who will enter industry as technicians, there would still be room within industry for the upgrading of skilled workers into technician ranks. Most of the skilled workers would have knowledge and skills in a specified trade or operative occupation. In these circumstances, it would be necessary to develop at a future date courses for such workers to enlarge their knowledge in the broader technician specialities so that they can fulfil their functions as technicians. For such skilled workers, the question of a minimum entrance level of general education, e.g., the Higher Secondary level, will not apply but their upgrading education and training would introduce the functional items of general education which are required for their proper performance as technician. This question is further dealt with in paragraph 54 below:

Length of Courses:

33. As discussed earlier, we have at present both the two-year and the three-year courses for technicians. It is recommended that the length of the technician pre-employment preparation after higher secondary be standardised. It is found that courses which are organised in technical institutions in India (excepting the 2-year technician course) have a total time requirement of 5,000-8,000 hours. (See Table X in Chapter III). The USSR technicum programme includes more than 6,000 hours. The 4-year sandwich course in mechanical engineering organised by some of the industrial enterprises in Calcutta is of more than 8,000 hours. If a proper balance is to be maintained between the study of fundamentals of science and technology and the intensive training in a selected technician speciality, then it seems desirable to aim at about 7,000 hours for both the institutional study as well as industrial training for future technician courses. This can only be obtained through a 4-year full time programme of training arranged on a sandwich pattern.

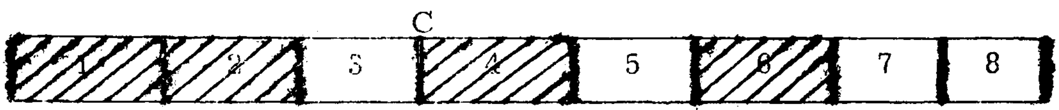
It is thus proposed that technician courses be organised as a 4-year programme after Higher Secondary or equivalent education for those who have taken technical and/or science subjects. Apart from the different objective of these courses and the emphasis in the programme of studies on applied technology, the technician courses will be distinguished from the engineering degree courses by the fact that, though both the courses take students at the post-higher secondary stage, the graduates of an engineering college would require 5 years of institutional work followed by training in industry for another one or two years, while a technician will require 4 years of education and training in industry, suitably integrated into the programme.

34. If it is assumed that during a 6-month period or blocks, the following number of hours will be available in institutional and industrial parts of the programme:

Institutional	=	22 Weeks x 36 hours	=	792 hours
Industrial	=	24 Weeks x (40-48 hrs (at 40 hours per week),	=	960 hours

then the following alternative patterns of educational preparation may be considered:

PATTERN 1



Blocks 1 and 2:	Institutional, with 1 day a week release to industry for general industrial exposure.
Block 3 :	Industrial Training in Industry or related Institution for basic industrial skills acquaintance.
Point C :	Exercises choice of speciality.
Block 4 :	Institutional, with initiation on speciality.
Block 5 :	Industriai Training, with initiation speciality.
Block 6 :	Institutional, with emphasis on speciality.
Blocks 7 and 8:	Industrial Training, may be coupled with employment; but 1 day a week release to Institution.

PATTERN 2

Blocks 1 and 3:	Institutional, for general development in borad branch of engineering.
Blocks 2 and 4:	Industrial, for general industrial exposure and for basic industrial skills acquaintance.
Point C :	Expercises choice in the speciality.
Blocks 5 and 7:	Institutional, with initiation and subsequently emphasis on the speciality.
Blocks 6 and 8:	Industrial, with initiative and subsequently emphasis on the speciality.

35. In both these patterns it is seen that the total institutional and industrial hours are the same, amounting to a total of 7, 008 hours as follows:

		Hours
Institutional	=	3, 168
Industrial	=	3, 840
		7, 008

36. The basic points to be taken into consideration in making a selection between these and other alternatives are:

(a) Industry should be closely involved in the programme. In Pattern 1, industry is involved during the 1st year, to the extent of 1-day a week. In Pattern 2, industry's involvement starts at the end of the first 6-months.

(b) For the engineering degree courses, the first period is devoted to broad development in all branches of engineering (a mechanical engineer gets acquainted with civil and electrical engineering as well before he exercises a choice, if he has not done it initially). For technician courses, the first period has to be devoted to broad development in all specialities within the broad branch of engineering and technology (a machineshop technician gets acquainted with other specialities within the mechanical engineering speciality, e.g., I.C. Engines, foundry, tools and dies, etc. and to a minor extent with other branches of engineering which have a bearing on his work). The time made available in the course should be sufficient for this development.

(c) There should be adequate time made available both for instruction, drawing and design, and for practical work within the institutions and in industry so that detailed technological knowledge and skills in the speciality are developed in the students. This also means that the period when the choice of the speciality has to be exercised cannot be deferred too long towards the later half of the 3 or 4-year period.

(d) It would be preferable not to think of different lengths of courses for different technician specialities at present as shorter courses may result in narrower specialisation with possible resulting problems of mobility. In developing the curriculum, wherever a certain grouping of subjects leads to a shorter total length of course for the speciality, it would be preferable to enlarge the coverage of the speciality and retain a standard 4-year programme for all technician specialities.

37. It is therefore suggested that a few pilot syllabuses in completely unrelated fields be developed to find out whether four terms in the institution would enable the attainment of these objectives or could the period be reduced. In addition, further consultations be held with industry to find out which pattern would be more acceptable to them.

38. It may be noted that according to Pattern 1 the student/trainee leaves the institution by the end of the third year, whereas in Pattern 2, he leaves at the end of $3\frac{1}{2}$ years. The Board for examination of the student may be composed of experts drawn from both the institution and industry. Both these patterns would involve admissions at 6-monthly intervals.

Syllabus Content of the Programmes:

39. Since admission to technician courses would be from the level of the Higher Secondary students, the curricular content would be reduced to the extent science, mathematics and applied science subjects are covered in the Higher Secondary courses beyond the 10-year schooling period. The curriculum content of technicians courses should aim at the technician, on completion of his programme of education and training, going on to a job in industry with the least amount of further training in industry. For this purpose, he should have adequate knowledge of the chosen field of technology, an acquaintance with the manual skills involved in that particular speciality, and knowledge and skills in the supervisory responsibilities of a technician. The theory side of technological knowledge to be imparted in the programme should be broad based enough so that as and when technology changes in that speciality, he could adapt himself quickly either through "own-time" reading or through short specialised reorientation courses. On the other hand, his knowledge and understanding of technology in his speciality should be deep enough so that he can be really useful to industry and guide the skilled workers under him, in that area of speciality.

40. The course will, therefore, have to have a proper balance between theory and practice. This can be achieved by a sandwich pattern of education and training which would bring him close to practices in industry.

41. Table X in Chapter III gives a comparative picture of the curricula content of technician courses in India and in selected countries abroad. It will be seen from this comparison that the total number of hours utilised for technician programmes varies between 1, 500 hours and 8, 000 hours. This variation arises largely from the length of the courses. In the Indian pattern, the three-year diploma course has about 2, 300 hours of instruction and 5, 500 hours of training out of which about 4, 400 hours are not actually taken up for training as commented upon earlier. On the other hand, the sandwich courses in India have about 2, 000 hours of instruction and 6, 000 hours of training which shows a very heavy bias of practical training and less attention to theoretical development. As against these patterns in India, it is seen that the technicums in the USSR provide for about 4, 000 hours of instruction and 2, 400 hours of training. In the Schools of Engineering in Germany, where the students are admitted after

an extensive period of apprenticeship in industry, there are 4,500 instructional hours.

42. In Indian conditions, where most students have not been exposed to an industrial environment, it would be necessary to provide some time for this exposure before they are involved in practical work in their area of speciality. This means that industrial training will occupy an important place and consume more time than in most technician courses in advanced countries. It would also seem advisable to develop a curriculum pattern which provides for about 1,000 hours of practical work in the selected speciality field within the institution. The distribution of total time among the various broad subject and activity areas may be as follows:

		% Time distribution
Institutional Work		45-55%
Consisting of:		
(a) Non-speciality Subjects	30-35%	
(b) Speciality Subjects	10-15%	
(c) Humanities and Supervision	10%	
Training		45-55%
Consisting of shop work in the Institution and training in industry depending on facilities developed in the institution.		100%

43. After the Working Groups suggested in paragraph 19 have determined the grouping of the technician specialities, it would be necessary to set up Syllabus Committees for each one of the specialities. These committees should develop:

(a) detailed syllabuses for each speciality,

(b) a list of equipment and physical facilities needed for institutions providing technician training in these specialities.

Teaching Staff:

44. Before a programme of revising the technician courses is introduced, it will be essential to initiate teacher training programmes for such technician courses. The teachers for these technician courses cannot be suitably drawn entirely from graduates in the broad fields of engineering firstly because the technicians specialities are narrow and therefore their understanding of these specialities would have to be deeper. Secondly, instructions in each one of the subjects will have to have a much greater practical orientation than those provided for in degree courses. It might, therefore, be necessary in the first place to make firm arrangements with industry for ensuring the services of a few practising engineers from the industrial establishments to undertake teaching assignments. Simultaneously steps may be taken to establish teacher training institutions or even summer courses for existing teachers in technician training institutions in cooperation with industry and other organisations.

45. It would also be necessary to review the remuneration system for teachers in these revised programmes so as to attract the best talent of the type needed for technician development.

Training Arrangements:

46. The practical bias to technician courses is to be imparted through a practical orientation in the instruction, as well as through more intensive, planned and supervised training programmes. As all physical facilities and equipment needed for imparting training cannot obviously be made available in the technician training institutions, arrangements will have to be made with industry for these training programmes. Therefore, the crux of the problem of training lies in the type of industry-institution collaboration that can be developed.

47. In order to develop this relationship the following arrangements are recommended:

(a) A major body of students in technician courses should be industry-sponsored, i. e., they should be recruited and placed by industry in the institutions or recruited by the institutions with the advice of representatives of industry. While a major body of students should be so placed by industry, there should also be an additional group not sponsored by industry, but selected by the institution, to meet the expanding requirements of new industrail establishments. The proportion between attached and unattached students may be determined on a 5-yearly basis for each technician speciality.

(b) The direct costs of developing and operating technician training programmes should be borne by Government so that industry does not feel that this is an additional burden being imposed on it. Till the period when the student exercises a choice in the technician speciality, no stipends may be paid (excepting merit scholarships arising from results of previous examinations, or stipends to scheduled caste students). Stipends at an agreed level may be paid by industry, after the selection of the technician speciality.

(c) Representatives from industry should be associated in the governing councils of each technician training institution. Moreover persons from industry should be drawn to the institutions for imparting instructions, and instructional staff from these institutions should have access to industry to get acquainted with practices and developments.

(d) Training programmes should be carefully planned jointly by industry and institution representatives, and closely supervised and controlled. No training period should be allotted to uncontrolled "training" of the observational type. Even in subjects where observational training is envisaged, it should involve a report writing by the student so that he takes an interest in his work and this should preferably be checked in the industry.

(e) Some shop facilities will have to be established within each technician training institution. These shops could take up work for industry wherever facilities can be spared. In a number of process types of technology, equipment and production facilities cannot be duplicated in these institutions, but testing and laboratory facilities could be developed in these institutions. Over and above training arrangements in industry, it is suggested that training arrangements could be made in other organisations and institutions such as:

Research laboratories
Proto-type factories
Training shops in industry, etc.

(f) The head of the institution should be selected, keeping in view that he has to play a key role in developing this contact with industry. Thus he has to have a helpful attitude to industry, be able to develop confidence from industry and be sociable in nature.

(g) These institutions should be located in the vicinity of industries they serve.

(h) It should be possible to establish technician training institutions in localities which do not have manufacturing industry, by selecting technician specialities in agriculture, or agro-based industries, or construction industries (where training may be with P. W. D. or Rural Engineering Organisations).

Diploma or Degree:

48. At present there seems to be a heavy bias among school leavers for admission to degree courses in engineering and technology. Several recommendations have been made earlier by various bodies to improve the status given to the outturn of polytechnic institutions. Whereas the question of improving the status of the present type of products of polytechnic institutions may continue to receive attention, it is felt that with the proposed revision in the standards of admission and the curriculum content of the courses, it would seem desirable to consider a revision in the diploma which is given to these students.

49. Sir Willis Jackson had recommended in a Conference on Education and Training of Engineering Technicians in March 1963 that corporate members of professional engineering institutions should describe themselves as "chartered engineers" and the designation "engineer" might then be utilised for the highly qualified group, and "engineering technicians" serving as the title for the less well-qualified members of the technician body. Suggestions have been made in the United States to designate engineering technicians as "application engineers" or "liaison engineers" or "technologists". In a report of the IAMR, it had been suggested earlier that the award on completion of a technician course of an improved type should be given the status of an "Associate Degree". Other informal suggestions from time to time have referred to the award as a "Technician Degree", "Diploma in Technology", etc.

50. Since it is not being proposed that these courses be brought under the purview of universities, it would therefore be inappropriate to call these awards as fulfledged degrees. The alternatives seem to lie

between "Associate Degree" or "Higher Diploma" or "National Technician Diploma", or even "Diploma" with suitable endorsements about the period/ type of courses completed. Any of these terms if used should not be confusing in respect of other levels of technological qualifications. For example, the award given on completion of a period of apprenticeship under the Apprenticeship Act is termed National Apprenticeship Certificate.

Institutions for Technician Training:

51. Even though the revised programmes for technician training would provide for a higher technological content, it is not suggested that these programmes be taken up in engineering colleges alongside degree courses. The question of combining degree and diploma institutions has been discussed in the past, and it does not seem necessary to reopen this question again. The term "polytechnic" has been used in most cases for institutions engaged in technician education/training. It is suggested that this term be continued. However, since there would be a period of dual existence for polytechnics which may have changed over to the new system and those which may not have changed over, it is suggested that some form of nomenclature to distinguish between the two types during the transitional period be adopted. Consideration might also be given to introducing a conversion course for the products of existing polytechnics so that they can take advantage of the new technician courses, which would obviously be introduced at selected industrial centres.

52. It would be necessary to establish national standards in regard to the quality of education and training to be provided in this programme just as has been done in the apprenticeship programme. An inspection machinery as well as an examining body would also be necessary for this purpose.

53. In order to carefully work out the programme, it is necessary to try out the scheme in the field by selecting some States or some industries or some localities where there is an industrial concentration. The curriculum development, physical facilities required, assessment systems, nature of collaboration with industry and other matters can be worked out in detail, their implementation watched closely and modified in the light of experience before the programme is generally extended throughout the country.

54. Just as professional bodies, such as the Institution of Engineers, Institute of Chemical Engineers, Institute of Metals, etc., have been set up, which have the responsibility for conducting examinations for entry into associate membership and membership status of persons not having professional level qualifications in engineering and technology, it would be necessary to promote the establishment of technician associations either as independent corporate bodies or as subsidiary bodies to the professional institutions, which would cater to the technological interests of technician personnel. They would also be the promoting bodies for the development and standardisation of part-time courses for the advancement of craft and trade personnel into technician ranks, and conduct examinations for the same. Liaison of these corporate or sub-corporate bodies with the central organisation at government level will have to be maintained so that standards developed at national level are adopted for examinations conducted by these bodies for the promotion of technician personnel form craft levels.

55. After the programme of implementation gets into its stride, it would be necessary to review the requirements of engineers with degree qualifications as such as development at polytechnic level is likely to have a considerable impact on the employment pattern of degree holders in engineering in relation to the outturn of middle level technicians for industry.

CHAPTER II

THE MIDDLE LEVEL TECHNICIAN IN INDUSTRY

Definitions and Role of a Technician:

56. The object of this enquiry into technician manpower requirements in industry is to provide certain guide-lines for policy makers in regard to establishment of facilities for their education, training and development. The enquiry obviously covers the qualitative angle as well as the quantitative angle. In examining the qualitative aspects, one is drawn into such questions as the definition of a technician, the role that he plays in an industrial undertaking and the parameters of his tasks and responsibilities, and finally his educational and experience preparation. The last mentioned item will be examined and discussed in detail in Chapter III. In examining the quantitative aspects, it is to be recognised that there are two basic parameters along with other minor ones. The first is the technician/engineer ratio in industry and the second is the engineer/labour force ratio. The second parameter, obviously, has a strong influence on the technician/engineer ratio as a relatively high concentration of engineers in the labour force as a whole or in individual industries or undertakings, is likely to result in a relatively low technician/engineer ratio unless deliberate attempts have been made to keep the latter ratio high.

Who is a Technician:

57. Preliminary to examining other qualitative and quantitative criteria, it is necessary to examine "who is a technician" in industry. A detailed study of this subject reveals a wide variety of definitions: some have defined it in terms of job titles, some on the basis of job requirements, and duties, responsibilities and/or functions, some on the basis of place he occupies in the total job hierarchy, and others on the basis of educational levels.

58. A definition based on his status in the employment hierarchy is to be found in a part of a definition given in an UNESCO/ILO pamphlet on Technical and Vocational Education and Training:

> The term "technician" applies to persons working in occupations requiring knowledge of technology and relative sciences between that of a skilled worker and engineer/technologist.

59. A definition based on job-requirements, duties, responsibilities and functions may be found in the one adopted at a Conference of Representatives from the Engineering Societies of Western Europe and the United States (1953):

> An engineering technician is one who can apply in a responsible manner proven techniques which are commonly understood by those who are expert in a branch of engineering, or those techniques specially presented by professional engineers. Under general professional engineering direction, or following established engineering techniques, he is capable of carrying out duties which may be found among the list of examples set out below.
>
> In carrying out many of these duties, competent supervision of the work of skilled craftsman will be necessary. The techniques employed demand acquired experience and knowledge of a particular branch of engineering, combined with the ability to work out the details of a task in the light of well-established practice. An engineering technician requires an education and training sufficient to enable him to understand the reasons for and purposes of the operations for which he is responsible. The following duties are typical of those carried out by engineering technicians:
>
> Working on design and development of engineering plant and structures; erecting and commissioning of engineering equipment and structures; engineering drawing; estimating, inspecting, and testing engineering construction and equipment; use of surveying instruments; operating, maintaining and repairing engineering machinery, plant and engineering services and locating defects therein; activities connected with research and development, testing of materials and components, and sales engineering, servicing equipment, and advising consumers.

60. A definition which incorporates educational attainments may be found in the one adopted for U.K. in the Survey of Qualified Scientists, Engineers and Technologists and Technicians and other Technical Supporting Staff (1965)*:

> Technicians and other technical supporting staff occupy a position between that of the qualified scientist, engineer or techno-

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* Report on the 1965 Triennial Manpower Survey of Engineers, Technologists, Scientists and Technical Supporting Staff. Cmnd 3103. HMSO. London, page 48.

logist on the one hand, and the skilled foreman or craftsman or operative on the other. Their education and specialised skills enable them to exercise technical judgement. By this is meant an understanding by reference to general principles, of the reasons for and the purposes of their work, rather than a reliance solely on established practices or accumulated skills.

61. A similar, but more descriptive of the level of attainment and curricula content may be found in Final Report of the Evaluation of Technical Institute Education conducted by the American Society for Engineering Education (1962)*.

Engineering technology is concerned primarily with the application of established scientific and engineering knowledge and methods. Normally engineering technology is not concerned with the development of new principles and methods.

Technical skills such as drafting are characteristic of engineering technology. Engineers graduated from scientifically oriented curricula, (See ASEE Report on the Evaluation of Engineering Education), may be expected to have acquired less of these skills than previously and the engineering technician will be expected to supply them.

The Engineers' Council for Professional Development (ECPD), adopting the recommendations in the above final Report revised their statement of objectives and Procedure for accreditation of engineering technology programmes. The following definition appears in that statement**:

An engineering technician is one whose education and experience qualify him to work in those areas of engineering which require the application of established scientific and engineering knowledge and methods, combined with technical skills, in the support of engineering or scientific activities toward the accomplishment of engineering objectives.

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* Final Report of the Evaluation of Technical Institute Education, American Society of Engineering Education, 1962, page 12.

** 31st Annual Report, Engineers' Council for Professional Development, New York, 1964.

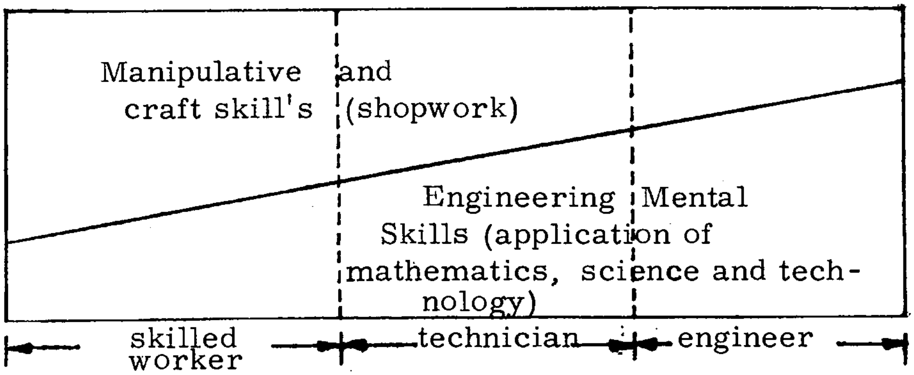
...If the term 'engineering technician' is restricted in its application to the upper portion of the range between the craftsman and the engineer, considerable future confusion can be avoided.

Diversity of Definitions:

62. It may be seen from the above that there is no single universally accepted description of the role of the middle level manpower at the technician level. One fact emerges, is that the differentiation of engineers (or technologists) on one hand with technicians on the other is not a simple matter. Secondly, the further study of quantitative requirements of technicians and particularly the engineer/technician ratio will depend largely on the definition or definitions used. If these persons are identified on the basis of educational levels— an engineer is a degree holder and a technician is a diploma holder in Indian conditions— the method flounders on those situations where a degree holder is under-utilised and fills the role of a technician or where a diploma holder actually performs the role of engineer. Further complication arises from the existence of engineering "practicals", who have neither degree or diploma qualifications, and where such personnel are classified as a separate category or in one of the two categories. The only rational answer can possibly be derived from a study of job descriptions. The Institute has designed a study on the Educational Content of Engineering Jobs to be taken up on a pilot basis, but such studies are time and resource consuming, and a solution to the existing problems of technician manpower in India cannot wait till the completion of such studies, though their results, when available, may help in refining the action taken or policies already determined.

Common Feature in Definitions:

63. Several conclusions however emerge from the above study of definitions. In the first place it is to be understood that the total content of engineering or technological tasks and responsibilities in an undertaking may be divided among different categories and levels of personnel in a variety of ways. If we distinguish between tasks requiring manipulative skills and those requiring engineering mental skills, then the graded spectrum may follow the pattern indicated at page 31 as between a skilled worker, a technician and an engineer.



This grouping can be further subdivided to distinguish between skilled and highly-skilled workers, between technician and laboratory assistants, between engineering specialists and professional engineers. But it will be evident that the contents of the tasks will vary depending on where the dividing lines are placed. The location of these demarcating lines depends on certain traditions in the country and industry concerned, the pattern of industrial production and other forms of industrial activity, the stage of scientific and technological development of the speciality, and several other factors.

64. Secondly, there are several common features in these definitions. They are as follows:

(a) A technician, in terms of knowledge and skills, is in between a skilled worker on the one hand and the engineer/technologist on the other. He is not however an extension of the skilled worker in terms of his skills, nor a diluted version of a professional engineer. He has a distinct place and role.

(b) The technician's position requires that by virtue of his education, training and experience, he understands the details of technological "knowhow" as laid down by the professional engineer, and translates the same into action as technological "do-how" and communicates to the skilled worker.

<u>Characteristics of Technician Employment:</u>

65. The purpose of studying employment characteristics, particularly the engineer/technician ratio and engineer/workforce ratio, is to facilitate the quantitative analysis of requirements of technicians. However, the main purpose for which the engineer/technician ratio is often discussed, is to assure that the engineer is not required by a

shortage of supporting personnel to divert his attention from duties requiring the full measure of his ability to tasks which could as easily be performed by persons with less education. This concern is expressed in order to avoid making engineering/technological education, top heavy.

Categories of Technicians:

66. As discussed earlier, the possibility of studying this pattern of employment is beset with many problems. The first of this is the definition as to his level. The second as to the categories to be included, for example should it include engineering technicians, research laboratory technicians, industrial laboratory technicians, draughtsmen, surveyors, and science technicians. Draftsmen and Surveyors could also be lumped with engineering technicians, but practices vary in this regard from country to country.

The Importance of the Technician/Engineer Ratio:

67. Studies of engineering and technician manpower in developed countries reveal that the ratio of technicians to engineers is an important issue for them as well. In his study of professional manpower in the USSR, Nicholas de Witt stated that in 1928 the Russians had used comparisons between Russia and German industries to decide that "a ratio of one professional engineer to two or three semi-professional technicians should be maintained in Soviet large-scale industry"*. Data presented in De Witt's study indicates that ratio of technicians to engineers now is between 2.5 and 3.0 in most of the broad industrial groups in USSR.

Country Variations:

68. The US Engineering Manpower Commission, in its report (1962) analysing the situation in the United States stated that "it is estimated that the desirable support for each professional technical person should be between one and four technical aides for one professional scientist or engineer engaged in scientific work. This variation depends to a large extent upon the type of work involved and the experience and status of the individual scientist, engineer, or technician. Yet recent evidence continues to show that the national ratio of technician to professional engineer remains approximately 0.7 to 1.0"** Figures compiled by the U.S. National Science Foundation† show that the ratio for U.S. industry

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* Education, Manpower and Economic Growth, Harbison and Myers, McGraw—Hill, New York, 1964, p. 86.

** Demand for Engineers, Engineering Manpower Commission, U.S.A., 1962.

† Scientific and Technical Manpower Resources - 1962, National Science Foundation. 1964.

is 0.8 to 1.0, which is very close to the estimate of the Engineering Manpower Commission. In only a few industrial groups does the technician/engineer ratio exceed 1.0, and the highest ratio for any group is only 1.3.

Variations in Major Sectors of Industry:

69. The employment of engineers and technicians spreads over several sectors of the economy, depending upon, among other things, the level of economic development and the priorities assigned to the programmes of development in each of the sectors. Variations in the pattern of engineering manpower and in the technician/engineer ratio, by the major sectors of industry, are given in Table I. The data available for the USSR, India and United Kingdom have been adjusted to provide a comparison.

TABLE I

Technician/Engineer Ratio, by Sectors of Industry

(numbers in thousands)

Sectors of Industry	USSR (1959)			India (1961)			U.K. (1965)		
	Engineers	Technicians	Ratio of Col. (3) to Col. (2)	Engineers	Technicians	Ratio of Col (6) to Col (5)	Engineers, Technologists and Scientists	Technicians	Ratio of Col (10) to Col. (9)
1	2	3	4	5	6	7	8	9	10
Mining and industry	443	1,025	2.4	19	19	1.0	101.6	404.1	4.0
Construction	82	166	2.0	10	9	0.9	7.2	46.4	6.4
Transport and communication	68	212	3.1	4	5	1.3	4.5	42.9	9.1
Others (teaching, research and services)	449	242	0.5	25	42	1.7	97.9	128.5	1.3
Total	1,042	1,645	1.6	58	75	1.3	211.2	621.9	2.9

Source: 1. Education and Professional Employment in the USSR, Nicholas de Witt, National Science Foundation, Washington, 1961, Tables VI-C-5. P at page 798 and VI-C-5-SP at page 802.

2. Stocktaking of Engineering Personnel, Institute of Applied Manpower Research, 1963, Table 44 at p. 75.

3. Report on the 1965 Triennial Manpower Survey of Engineers, Technologists, Scientists and Technical Supporting Staff, Cmnd. 3103, HMSO, London, 466, Table 4 at pages 56-57.

Variations within Manufacturing Industry:

70. That the ratio does vary from country to country and from one stage of economic development to another, is evident from the above data. But more interesting is data relating to variations from one manufacturing industry to another. Table II gives the density of employment of engineers, technologists, scientists, technicians and technical supporting staff in different manufacturing industries, as presented in the UK 1965 Triennial Manpower Survey*. The last two columns of the technician/engineer ratio and engineer/scientist ratio have been added for our purposes. It may be seen that there is a wide variation in the engineer/technician ratio as between industries. The average is 4.1 and the variations are between 1 to 6.

71. A further analysis of data from four countries to find out whether certain industrial groups consistently feature technician/engineer ratios significantly higher or lower than the national average is presented in Table III. The analysis indicates that the technician/engineer ratio is most often considerably higher than the average in textiles, machinery or engineering, vehicles, food and drinks and light manufacture. The most persuasive explanation for these patterns is that the industrial groups with the most complex technology would require a relatively high number of professional engineers and hence a low technician/engineer ratio, whereas groups with uncomplicated technology require a lower concentration of professional people and are characterised by a high technician/engineer ratio. The chemical industry and electrical equipment industry conform to the first pattern; textiles and light manufacturing to the second. Another possible explanation may be that process industries are now-a-days highly automated, thus requiring less technicians. But an attempt to establish a consistent theory is nullified by the fact that the wood and paper industries evidence a ratio only slightly higher than the average while heavy machinery industry, which suggests a more complex technology, has a ratio much higher than the average. Another way of examining the consistency of ratio

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* Report on the 1965 Triennial Manpower Survey of Engineers, Technologists, Scientists and Technical Supporting Staff, Committee on Manpower Resources for Science and Technology, HMSO, Cmnd. 3103, p. 60.

TABLE II

Density of employment of engineers, technologists and scientists, technicians and other technical supporting staff in U.K., by industry

Manufacturing industry

Industry of employer	1962 Total employees (000's)	1962 Engineers, techno-logists and Scientists (1) %	1965 Total employees (000's)	1965 Engineers and techno-logists (1) %	1965 Scientists (1) %	1965 Engineers, techno-logists and Scientists (1) %	1965 Tech-nicians (1) %	1965 Technician/ Engineer Ratio Col (8)÷(7) %	1965 Engineer/ Scientist Ratio Col (7)÷(6) %
1	2	3	4	5	6	7	8	9	10
Food, drink and tobacco	724	0,4	714	0,2	0.4	0.6	1.8	3.0	0.5
Chemicals and allied industries	446	4.1	437	1.5	3.1	4.6	7.7	1.7	0.5
Excluding mineral oil refining	416	3.9	410	1.3	3.0	4.2	7.6	1.7	0.4
Mineral oil refining	30	6.4	27	4.8	4.5	9.2	10.1	1.1	1.0
Metal manufacture	595	1.0	602	1.0	0.2	1.2	4.5	3.8	5.0
Mechanical engineering	1,766	1.1	1,772	1.1	0.1	1.2	6.6	5.5	10.0
Electrical engineering & electronics	753	2.4	808	1.9	0.7	2.6	9.4	3.6	2.7
Electrical engineering	461	...	478	1.6	0.3	1.9	7.5	4.0	5.3
Electronics	292	...	330	2.4	1,2	3.6	12.2	3.4	2.0
Vehicles, etc.	953	1.2	948	1.1	0.1	1.2	7.1	5.9	10.1
of which-motor vehicles	434	0.5	504	0.5	...	0.6	3.6	6.0	...
Aircraft	287	2.5	254	2.2	0,5	2.7	16.2	6.0	4.4
Textiles clothing etc.	1,432	0.3	1,295	0.2	0.2	0,4	2.1	5.2	1.0
of which-cotton, flax and man-made fibres	273	0.8	233	0.5	0.5	1.1	3.8	3.5	1.0
Other manufacturers	1,463	0.4	1,493	0.3	0.2	0.5	2.4	4.8	1.5
Total	8,133	1.1	8,070	0.8	0.4	1,2	4.9	4.1	2.0

(1) As a percentage of total employees.

Note . As "technicians" cover all the technical staff supporting engineers, technologists and scientists, the ratio in Col. (9) of the Table is worked out between all technicians (Col. 8) and all qualified engineers, technologists and scientists (Col, 7).

TABLE III

Technician & Engineers in Broad Industrial Groups—4 Countries

INDUSTRIAL SECTOR	EMPLOYMENT FIGURES: Ireland (2)			U.K. (3)			U.S.A. (4)			USSR (5) (000's)			RATIOS: Technician/Engineer				Engineers/Labor Force			
	Engi-neers	Tech-nicians	Labor force	Engi neers	Tech-nicians	Labor force	Engi-neers	Tech-nicians	Labor force	Engi-neers	Tech-nic-ians	Labor force	Ire-land	U.K.	U.S.A.	USSR	Ire-land	U.K.	U.S.A.	USSR
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Food, drink, tobacco	114	142	9776	3773	12724	714000	10400	13900		22.5	63.0	1713	1.3	3.4	1.3	2.8	.0117	.006	NA	.0131
Textiles	30	157	6228	4619	27741	1295000	4100	3700		NA	NA	NA	5.2	6.0	0.9	NA	.0048	.004	NA	NA
Chem., Paint	101	202	4743	17566	33749	437000	39200	43400		22.2	45.4	537	2.0	1.9	1.1	2.0	.0213	.046	NA	.0413
Electrical equip.	13	36	1961	18071	76107	808000	112000	84900		11.1	23.1	252	2.8	4.2	0.8	2.1	.0066	.026	NA	.0440
Machinery	NA	NA	NA	18275	117549	1772000	64000	63400		NA	NA	NA	NA	6.4	1.0	NA	NA	.012	NA	NA
Cement, bricks, glass pottery	28	98	3065	NA	NA	NA	7500	4700		14.7	41.4	1007	3.5	NA	0.6	2.8	.0091	NA	NA	.0146
Fabrication metal products	29	114	3388	6272	27138	602000	22700	24600		(Includes Machinery) 158.9	390.3	5055	3.9	4.3	1.1	2.5	.0086	.012	NA	.0314
Vehicles	6	20	1415	2254	18053	504000	20800	15900		NA	NA	NA	3.3	8.0	0.8	NA	.0042	.005	NA	NA
Wood, paper cork	21	52	2285	NA	NA	NA	8800	7600		15.4	44.4	2418	2.5	NA	0.9	2.9	.0092	NA	NA	.0064
Light manufacturing	NA	NA	NA	6565	35799	1493000	6600	7200		17.0	132.9	2804	NA	5.5	1.1	7.8	NA	.005	NA	.0061

Notes . A. See Appendix I Notes for definitions.

B. The figures for U.K. in this table are somewhat different from those in Table II, as adjustment has been made here for those engineers who are working in technician positions i.e. Table II is an analysis of engineers and technicians in employment by educational levels, and Table III is an analysis by positions in industry classified by fuctions.

N.A. — Not available.

variations by industrial sector is given in Table IV. It is likely that data of four countries constitute too small a sample, but unfortunately very few countries have undertaken surveys indicating the position industry by industry.

TABLE IV

Deviation of the Technician/Engineer Ratio in several Industrial Groups from the overall Industrial Ratio - Data from four Countries

Country	Ireland	U.K.	U.S.	U.S.S.R.	Mean Dev. of Industrial Group	% of Sample Deviations in Same Direction*
Ratio-Mfg. Industry	2.3	4.7	0.8	2.5		
Industrial Group	Deviation From Overall T/E Ratio					
Food, Drink, Tobacco	-1.0	-1.3	+0.5	+0.3	-0.4	50
Textiles	+2.9	+1.3	+0.1	-	+1.4	100
Chemicals Paint	-0.3	-2.8	+0.3	-0.5	-0.8	75
Electrical Equipment	+0.5	-0.5	0.0	-0.4	-0.1	67
Machinery		+1.7	+0.2		+1.0	100
Cement, Bricks Glass, Pottery	+1.2		-0.2	+0.3	+0.4	67
Fabrication, Metal Products	+1.6	-0.4	+0.3	0.0	+0.4	67
Vehicles	+1.0	+3.3	0.0		+1.4	100
Wood, Paper, Cork	+0.2		+0.1	+0.4	0.2	100
Light Manufact.		+0.8	+0.3	+5.3	+3.1	100

* Zero Deviations are not included in the calculations of this column.

(See Notes in Appendix I).

72. In Table II, the engineer/scientist ratio does not show any relationship with the technician/engineer ratio according to the present pattern of employment in the United Kingdom. One would have assumed, that those industries which employ a large number of scientists compared to engineers, would employ a lesser number of technicians, but this trend is not discernible.

Size of Establishment Variations:

73. Another possible cause of variations in the technician/engineer ratio may be the size of establishments. Data on engineers and technicians, by size of establishment, obtained from the U.K. 1965 Survey*, are given in Table V. The last column on technician/engineer ratio has been added for our purposes. It is seen that though the technicians/workforce ratio consistently goes down with the reduction in size of establishment, the technician/engineer ratio consistently goes up with the reduction in size. This is more likely to be the global pattern and not confined to the United Kingdom only.

Variations due to Grouping of Specialities:

74. There also seem to exist considerable difference between countries in the manner in which a broad branch of engineering or technology is divided into technician specialities. A general examination of the pattern of division in USA and USSR of the broad branch of Mechanical Engineering seems to show the following:

U.S.A.**

(Includes Mechanical Engineering, Aeronautical Engineering and Textile Engineering)

Mechanical Engineering Technology
Mechanical Technology
Production and Machine Design
Tool Engineering Technology
Gas Engineering Technology
Diesel - Gas Turbine Technology
Internal Combustion Engineering
Automotive Technology

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* Ibid., p. 61.

** Technician Diplomas: ASEE, Journal of Engineering Education, July - August 1964.

TABLE V

Density of employment of engineers, technologists and scientists, technicians and other technical supporting staff in U.K. by size of establishment.

Size of establishment	Manufacturing Industry 1962 Total employees (000's)	1962 Engineers, techno-logists and scientists (1)	1965 Total employees (000's)	1965 Engineers and technologists (1)	1965 Scientists (1)	1965 Engineers techno-logists and scientists (1)	1965 Technicians (1)	1965 Technicians/Engineers etc Ratio Col. (8)(÷7)
1	2	3	4	5	6	7	8	9
500 or more employees	3,964	1.58	4,059	1.17	0.55	1.72	6.28	2.7
200 — 499 employees	1,472	0.79	1,485	0.63	0.26	0.89	4.04	4.5
100 — 199 employees	809	0.54	777	0.48	0.22	0.70	3.54	5.1
50 — 99 employees	1,146	0.44	1,085	0.37	0.20	0.57	3.23	5.7
11 — 49 employees	741	0.42	663	0.40	0.19	0.59	3.16	5.4
Total establishments with 11 or more employees	8,133	1.07	8,070	0.83	0.39	1.22	4.94	4.0

(1) As a percentage of total employees.

(See notes under Table II)

Air-conditioning, heating and refrigeration
Airconditioning Design Technology
Aeronautical Technology
Aeronautical and Astronautical Engineering Technology
Aeronautical Drafting
Aircraft Maintenance
Textile Engineering Technology.

U.S.S.R. *

(Includes Speciality Group 5: Machine Building and Instrument Construction)

Technology of Machine Building, Metal-Cutting, Tools and Instruments
Machinery and Technology of Casting Process
Machinery and Technology of Processing Metals under Pressure
Equipment and Technology of Welding Processes
Mechanical Equipment of Ferrous and Non-ferrous Plant
Mining Machinery
Peat Mining Machinery
Machinery and Equipment of Oil and Gas Fields
Agricultural Machinery
Lifting, Hoisting and Transportation Machinery and Equipment
Construction and Road Building Machinery
Machinery and Equipment
Railway Car Building
Automobiles and Tractors
Ship Building and Ship Repair
Printing Machinery
Machinery and Installations of Chemical Industry
Machinery and Installations of Food Industry
Machinery and Installations of Light and Textile Industries

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* Education and Professional Employment in the USSR, National Science Foundation, USA (Nicholas de Witt), pages 661-663 and 678.

Machinery and Equipment for Timber Industry and Forestry
Boiler Construction
Turbine Construction
Internal Combustion Engines
Ship Engines and Mechanisms
Ship Power Installations
Locomotive Building
Dynamics and Strength of Machine Design
Hydraulic Turbines and other Hydraulic Machinery
Refrigeration and Compressor Machinery and Installations
Optical Instruments
Instruments of Precision Mechanics
Geodesy Instruments
Cinematographic Equipment
Aircraft Construction
Aircraft Engines and Propulsion Devices
Aerodynamics and strength of air-crafts
Mechanical Equipment of Flight Devices
Tool and Die Engineering.

75. This comparison of the technician speciality subjects in one major branch of engineering in two different countries, indicates that a global study may reveal major differences. These differences in technician specialities do no doubt have their effect on the pattern of employment and on the technician/engineer ratio, but what this difference would be, is difficult to say without carrying the study much deeper. It seems that the U.S. pattern is based on technological subject divisions, but the USSR pattern is based on industry divisions.

76. The pattern of division will also have a bearing on the type and pattern of employment in the country or vice-versa. For example, in the field of Civil Engineering, the technician specialities could be grouped depending upon whether personnel is required for irrigation, highway and bridge construction, buildings and public works or public health and sanitation services. Alternatively, the grouping could be based on the activities of technicians such as surveying and estimating, supervision of construction, quality control or design and drawing. These groups would be different from the group of specialities based on technological subject divisions, viz., concrete technology, architectural design, technology of soils and foundations, etc.

Variation in Activity Groups:

77. Finally come the differences in the technician/engineer ratio arising out of differences in the type of activities or sectors of employment of technicians qualified in the same branch of engineering. For example, in Germany, it is stated that 42 per cent of technicians are employed in design work, 34 per cent in the planning and preparation of production and only 10 per cent in production. The occupational distribution of technicians is not available in any great detail for any country. However, an occupational survey* of the metallurgical technicians graduated from the Milwaukee School of Engineering (USA) revealed that as many as 36.7 per cent of the technicians were continuing education and 21.1 per cent were engaged in research work. Production occupations accounted for 21.1 per cent with another 9.6 per cent in testing and material evaluation. On the other hand, a study of the technician employment in an industry such as iron and steel industry in India gave an entirely different pattern**.

Departments	Per cent
Production and maintenance	24.7
Engineering services	20.3
Design	3.3
Construction	37.9
Others	13.8
	100.0

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* Evolution of a Mechanical Technology Programme, Edwin A. Meier, Technical Education News, McGraw-Hill Book Co., New York, Vol. XXII No. 1, 1962.

** Employment of engineers and diploma holders under Hindustan Steel Ltd., 1964.

Yet another pattern is indicated in the distribution of technicians in Denmark* by their broad occupational groups:

Occupational field	Percentage distribution of technicians, 1959
Laboratory technicians	45
Building construction technicians	14
Technical draughtsmen	18
Other technicians	23
	100

78. It would have been more than interesting if the above pattern could be compared with the employment of professional engineers and the variations in the ratio of technicians to engineer studied by these activity groups. But the data available for the purpose are extremely limited and incomplete. It may nevertheless be noted that there is a close relationship between the above pattern of technician employment and the corresponding educational preparation of the technicians, with particular reference to the *inter se* emphasis given in such preparation for the subject content and applied training in the technician speciality.

The Indian Structure:

79. Information is available relating to the employment of mechanical and electrical engineering personnel in India during 1964**. For the whole of the economy, the overall ratio of diploma holders to degree

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* *Ibid*, page 145.

** *Employment of Mechanical and Electrical Engineering Manpower in India, 1964*, Institute of Applied Manpower Research, New Delhi, 1965.

holders in these two branches of engineering is 1.2 (See Table VI), while the ratio for different industrial groups varies between 0.73 and 1.71. The two problems mentioned earlier as constantly distorting the picture also obtain here. The first is that diploma holders may not be identical with technicians nor degree holders with professional engineers. The second is that although the Report identifies a large number of engineering "practicals", it does not count them as either engineers or technicians despite the fact that many are employed in higher grade positions where the duties are those of the engineer and not that of the technician. What is needed is a study of the engineer positions and technician positions in a given industry rather than the qualification of engineering/technological personnel in position. If all practicals are counted with diploma holders as technicians, then the technician/engineer ratio in different industrial sectors will range between 1.7 and 3.6 with the aggregate ratio at 2.2 as per calculations shown alongside. This method does not account for those degree holders working as technicians and those diploma holders working as engineers. This situation will exist in every country. The 1965 Manpower Survey of Engineers, Technicians, etc., in U.K. * showed that about 11% of all qualified engineers, technologists and scientists were employed in technician positions. The other alternative is to count all engineering personnel working in Grades V and VI as technicians. This gives an aggregate technician/engineer ratio of 1.1. The truth of the Indian situation in this field, assuredly must lie between the two aggregate ratios of 1.1 and 2.2, but because the second method is possibly closer to the real situation, the ratio is likely to lie between 1.3 and 1.6. Though the situation is not too discouraging, the difference with the average technician/engineer ratio as indicated for U.K. for example, (See Table II), is quite large.

80. While Census data may be too general for this purpose, a sample drawn for two districts - Greater Bombay and Thana

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* Report on 1965 Triennial Manpower Survey of Engineers, Technologists, Scientists, and Technical Supporting Staff, Cmnd. 3103, HMSO, page 28.

TABLE VI

Adjustment of Data on Employment of Engineers and Technicians in India*

A. Calculation of Technician/Engineer Ratio from data as presented.

MEE degree holders - all grades:	24, 834
MEE diploma holders - all grades:	30, 668
Ratio diploma holders/degree holders:	30, 668/24, 834 = 1. 2

B. Calculation of Technician/Engineer Ratio, adjusted to include all Engineering Practicals as Technicians.

MEE practicals - all grades:	24, 167
MEE diploma holders - MEE practicals:	54, 835
Ratio diploma holders - practicals/ degree holders:	54, 835/24, 834 = 2. 2

C. Calculation of Technicians/Engineer Ratio, adjusted to classify all technical persons employed in Grades I to IV as engineers and all employed in Grades V and VI as technicians.

1. Employees, Grades I to IV

MEE degree holders:	20, 297
MEE diploma holders:	8, 674
MEE practicals:	9, 119
Total	38, 090

2. Employees, Grades V and VI

MEE degree holders:	4, 537
MEE diploma holders:	21, 994
MEE practicals:	15, 048
Total	41, 579

Ratio Technicians/Engineers:	41, 578/38, 090 = 1. 1

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* Data taken from "Demand and Supply of Engineering Manpower (1961-1975)", IAMR, New Delhi, 1965 and relate to mechanical and electrical engineering personnel.

(See Tables VII and VIII) shows rather a disturbing position in all sectors of economic activity, including "Manufacturing". For example in the manufacturing sector in Greater Bombay, there were 2,529 technical personnel below degree standard (Sr. No. 5) and 8,684 with technical degrees (Sr. No. 8). The same ratio is seen in other sectors of economic activity and also in Thana district. What however this may mean, is that there are few courses at certificate and Diploma level in technological occupations and most personnel working in such posts are "practicals". On the other hand, degree courses in engineering and technology are more highly developed.

Recommended Ratios:

81. Several authorities from time to time have recommended the adoption of certain technician/engineer ratios as desirable. Professor Harbison of Princeton is representative of those who contend that in developing countries "engineers often outnumber technicians by as much as three to one although the desirable ratio may well be one to three"*. The Colombo Plan Bureau report on technician training stated that "a normal staffing pyramid for many kinds of engineering work (is) 5 technicians to each engineer"**. In addressing the USAID Seminar on Problem of Manpower Planning, Development, Utilisation, Distribution and Administration, F. Fletcher Wellemeyer stated that "in the U.S., at present there are only 7 technicians for every 10 engineers. Occupational analysts feel that the proper ratio should be between 2:1 and 5:1. Because of the increasing shortage of engineers, the demand for technicians will surely rise". Closer to home the Engineering Personnel Committee (1956) had suggested† that the ratio should be at least in the neighbourhood of 1:3 and that special efforts require to be made in order to fill the gap existing in India. According

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* Education, Manpower and Economic Growth, Harbison and Myers, McGraw-Hill, New York, 1964, p. 86.

** Report on Training Facilities at the Technician Level in South and South East Asia, Colombo Plan Bureau, Colombo, 1961, p. 19.

† Report of the Engineering Personnel Committee, Government of India, Planning Commission (1956), p. 25.

TABLE VII

(Education and Employment)

Employed persons according to level of education in non-agricultural industry - Greater Bombay (all urban)

Sl. No.	Persons	0 and 1 Agri. Live-stock, Fore-stry, Mining Quarrying, etc. (excluding cultivators and agricultural labourer)	2 and 3 Manufacturing (including household industry)	4 Construction	6 Trade and Commerce	7 Transport, Storage and Communication	5, 8 and 9 Electricity, Gas, Water supply, other services and Misc. activities
1.	Illiterate	16,747	224,829	25,491	67,768	61,479	148,103
2.	Literate	4,973	186,549	8,286	78,233	41,688	97,810
3.	Upto Matric	2,670	194,094	6,481	94,594	44,134	87,290
4.	Matric	541	62,128	2,998	48,664	34,521	54,264
5.	Technical and below degree	13	2,529	337	348	544	1,757
6.	Non-tech. and below degree	23	498	64	424	142	1,674
7.	University degree other than tech.	78	9,261	375	11,431	4,908	20,132
8.	Technical degree	86	8,684	874	2,345	1,844	15,163

Data from Census of India, 1961.

Table B. III in Census and Table-2 (h) in Bombay Labour Market Survey Report.

TABLE VIII

(Education and Employment)

Employed persons according to level of education in non-agricultural industry--Thana Labour Market Area*

Sl. No.	Persons	0 and 1 Agri. Live-stock, Fore-stry, Mining, Quarrying, etc. (exclu-ding cultiva-tors and agri-cultural labourer)	2 and 3 Manufac-turing (includ-ing hou-sehold industry)	4 Cons-truc-tion	6 Trade and Comm-erce	7 Trans-port, Stor-age and Comm-unica-tion	5, 8, and 9 Electricity, Gas, Water supply, other ser-vices and Misc. ac-tivities
1.	Illiterate	3,948	19,110	1,963	6,980	4,241	13,051
2.	Literate	1,182	14,886	586	6,789	2,268	5,699
3.	Upto Matric	1,290	23,391	699	6,816	5,077	10,989
4.	Matric	145	6,931	277	2,739	6,023	8,201
5.	Technical and below degree	1	213	38	16	74	253
6.	Non-tech. and below degree	-	22	-	9	7	514
7.	University degree other than tech.	10	587	13	378	594	1,699
8.	Technical degree	7	716	28	67	124	1,242

* These figures are for Urban areas in Thana District.

Data from Census of India Table B.III in Census and Table 2(i) in Bombay Labour Market Survey Report.

to Sir Willis Jackson, * the optimum number of technicians for every engineer in India could be larger and not smaller, than that in England or Germany, keeping in view the fact that, for some time to come, most of the development activities in India would be in the form of incorporating and applying the products of technology developed in other countries. L. S. Chandrakant, of the Ministry of Education, in a report** on technical education, more conservatively states that "it is generally agreed that the right proportion of engineers to technicians is 1:2........ To this end, readjustment should be made deliberately in the demand as well as the supply of graduates and diploma holders, and a proportion of 1 to 2 should be aimed at, by the end of the Fifth Plan". The Education Commission† has recommended the reaching of an overall ratio of engineers to technicians of 1:2. 5 by 1975 and 1:3 or 1:4 by 1986.

Engineer/Labour Force Ratio:

82. Similarly, looking at the engineer/labour force ratio, George Payne,‡ reported that "British industry has traditionally leaned heavily on technician and craftsman, of whom it has maintained a well-rounded corps, the product of an elaborate system of apprentice training rather than formal academic education". He illustrates this point with figures: "In Britain 0. 8% of total employment by industry in 1956 were scientists and engineers; in US in 1954, 2. 7% were". Correspondingly we expect the technician/engineer ratio to be higher in UK than in USA. The inverse relationship between the two ratios is supported by statistics in Sweden where there are 1. 3 engineers for every 100 members of the labour force and only 0. 8 technicians per engineer. In Ireland the lower engineer/labour force ratio of 0. 01 is paired with a technician/

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* "Development of Technical Education in India — a brief report on the discussions with Sir Willis Jackson, held in the Planning Commission on January 19, 1966," Govt. of India, Planning Commission, pp. 2-3.

** Fourth Five-Year Plan of Technical Education — A Draft Report, L.S. Chandrakant, Ministry of Education, New Delhi, Nov. 1965, p. 12.

† Report of the Education Commission, (1964-66), Govt. of India, Ministry of Education, p. 373.

‡ Britain's Scientific and Technological Manpower, George L. Payne, Stanford University Press, Stanford, 1960, p. 65.

engineer ratio of 2.5. These may be seen in Table IX. The case of USSR is not really an exception even though both ratios are high: 0.017 engineer per labour force and 2.5 technicians per engineer. The USSR directed its policy to making both ratios high. However, Denmark with an engineer/labour force ratio of only 0.008 and a technician/engineer ratio of only 0.7, suggests that generalisation is still difficult and that use of two parameters is no more scientific than the use of one. A serious reservation about generalising on the basis of the technician/engineer ratio and the engineer/labour force ratio used in tandem is that a low technician/engineer ratio coupled with a high engineer/labour force ratio probably indicates that engineers are not being utilised effectively and that many of them are actually serving as technicians.

Conclusions on Employment Pattern:

83. The study on these two ratios indicates the danger of using inter-country comparisons on technician/engineer ratio and engineer/work force ratio for Indian planning. Firstly there are wide variations in these ratios and the question arises which country's example to follow. The evidence becomes more confusing when we learn that the first ratio is 0.8 in Denmark and Sweden, 1.6 in Belgium and France and 2.3 in Ireland (See Table IX). The existence of values less than one, indicates that the reverse situation in regard to desirable or normative pattern of technicians to engineers ratio does exist. Secondly, these ratios not only vary between countries, industries, occupational activities and sizes of establishments, but these ratios are vitiated by differences in definitions and conditioned by tradition, stage of development of the economy, the stage of development of the technology and by the manner of grouping of the technician specialities. The wide variations in ratios render impossible the development planner's job of determining a statistical trend which could serve as a target for this country's manpower programmes. Where definitional parameters are consistent, the difference in these ratios for the economy as a whole and for each sector of industrial activity, might indicate the existence of a situation requiring corrective action, which it does in the case of India, but the use of such ratios have major limitations for educational planning. Each country has to develop its own pattern based on the variable conditions discussed above and this is what is needed in India now.

Technicians and Engineers in Manufacturing Industry in various countries

Country	Univ. Trained Eng.	Other Trained Eng.	Total Trained Eng.	Tech.	Tech./Tot. Eng.	Labour Force	Tot. Eng./Labour Force
Belgium[1] (1959)†	48.4*	50.1*	98.5*	143.6*	1.5	1,566,000	.0098
Denmark[1] (1959)†	46.9*	37.1*	84.0*	53.5*	0.7		.0084
France[1] (1959)‡	NA	NA	109.7*	176.2	1.6	6,300,000	.0110
Ireland[2] (1964)	NA	NA	378.0**	871**	2.3	35,601**	.0106
Sweden[1] (1960)†	42*	89*	131.0*	105*	0.8	NA	.0131
Switzerland[1] (1955)†	NA	NA	14,440.0	17,100	1.2	NA	NA
U.K.[3] (1965)	NA	NA	84,529.0	398,374	4.7	NA	NA
U.S.A.[4] (1962)	NA	NA	480,300.0	379,500	0.8	NA	NA
U.S.S.R.[5] (1959)	NA	NA	343,300.0	860,900	2.5	20,205,000	.0169

N.A. = Not Available.

* Number per 10,000 in the working force.

** Number from sample of 120 firms only.

‡ The data for these countries includes the number of engineers and technicians in non-manufacturing industry.

(See Notes in Appendix I).

This conclusion is also borne out by another recent study based on an analysis of Employment Exchange statistics*. It shows that though the ratios of diploma/degree outturn from engineering educational institutions ranged between 1.8 to 2.5, these ratios among job seekers in the live registers of Employment Exchanges ranged between 6.3 to 7.3 as follows:

Subject of Study	No. of applicants on the live register at the end of June, 1966			Outturn during the year 1965-66		
	Graduate	Diploma holders	Proportion of Col. 3 to Col. 2	Graduate	Diploma holders	Proportion of Col. 6 to Col. 5
1	2	3	4	5	6	7
1. Civil	761	5,323	7.0	2,515	6,219	2.5
2. Mechanical	749	5,432	7.3	3,136	5,931	1.9
3. Electrical	587	3,677	6.3	2,320	4,279	1.8

This shows that even though a desirable ratio in the output of diploma and degree institutions may be achieved as per recommendations of planning bodies, and in fact the ratio recommended for 1975 has already been achieved in the field of civil engineering, industry has not been able to use the higher outturn of diploma holders and therefore a larger volume of diploma holders are accumulating in the live registers of Employment Exchanges. The problem may therefore be located in any one or all of the following:

(a) There is some thing intrinsically wrong in the educational specialisation of diploma holders,

(b) The quality of the final product from polytechnic institutions is not acceptable to industry,

(c) The employment structure in industry is such that it is unable to absorb the larger outturn of diploma holders.

The probable causes listed in (a) and (b) above may result in cause (c) or the latter may be independently caused. Therefore, it is considered to be a risky proposition to accept any pre-determined overall ratios of techniques to engineers for development of education facilities without taking into account the other factors discussed in this paragraph.

* A study on the supply of and demand for engineering degree and diploma holders - An analysis of Employment Exchange statistics, Directorate General of Employment and Training, Govt. of India, 1967, table 4, page 9.

CHAPTER III

TECHNICIAN EDUCATION AND TRAINING

PRESENT PATTERN IN INDIA

Technician Education at the Diploma Level:

84. The main educational programme for engineering technicians in India is offered in the polytechnics which conduct three-year diploma courses in different branches of engineering and technology with matriculation as the minimum admission requirement. These courses are wholly institution-based and generally academic and theoretical in content and method. The first year of the course is common to all the branches of engineering and includes a study of civil, mechanical and electrical engineering subjects. There is no specialisation in any particular technician speciality within the concerned branch of engineering and the courses lead to a general diploma in civil/mechanical/electrical engineering, etc. The courses provide for about 35,000 hours of instruction and practical work in the institution. Even though a course of practical training in industry for a period of 2 years is envisaged in the scheme for these courses, in actual practice, this is not undertaken for various reasons including the limited facilities for such practical training. Facilities exist for these diploma courses in 259 polytechnics in all the States and most of the Union Territories with a provision for an annual admission of about 47,000 students. The annual outturn in 1965 was of the order of 17,000 which is expected to be doubled by 1975-76*.

Two-year Technician Course:

85. In addition, facilities are available for 1,710 annual admissions created under a special programme for two-year 'technician' courses in engineering. These courses require Higher Secondary education as the minimum qualification for admission and are designed to train specialists at the middle level in specified sub-branches of engineering such as machine-shop and tool room technology, electronics, electrical technology, mechanical design technology, automobile and diesel technology, and civil

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* Report of the Technical Manpower Assessment Committee, Govt. of India, Ministry of Education, December 1966, para 23.

construction technology, etc. The course includes about 270 hours of instruction in the technical speciality and 1,300 hours of training in workshops. The total duration of the course is two years with 3,040 contact hours. It was expected that technical institutions would use these courses as a guide and that "progressively all the polytechnics in the country should change over to courses with the new approach, namely, preparation of specialists"*. At present, however, only 8 polytechnics offer these technician speciality courses in civil, mechanical and electrical engineering branches. The annual outturn from these courses was 660 technicians in 1965 which is likely to increase to 1,200 in 1975**.

Sandwich Course in Mechanical Engineering:

86. Efforts have also been made to formulate sandwich courses at the diploma level for training supervisory personnel for specific industry. The scheme for training of foremen and supervisors for mechanical engineering industry was formulated by the Ministry of Education in 1957†. This scheme recognised that the products from the three-year diploma courses in engineering/technology lacked practical experience and were not therefore able to meet the specific needs of supervisory positions in industry. It was also noted that as the duties and responsibilities of these supervisors in industry were well-defined, it was not necessary to provide for the same broad-base in the institutional study as in the conventional diploma courses. The sandwich course was accordingly proposed to include institutional studies of 46 weeks and industrial apprenticeship for 138 weeks within a period of 4 years. The course includes a study of the basic principles of all branches of engineering, humanities and mathematics and laboratory work for 1,970 hours. No workshop training in the institution is envisaged. The inplant training provides for advanced training in any one particular shop of the industry for 12 weeks and training in foremanship and supervision for 320 hours on a part-time basis. No specialisation was

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* Minutes of the 34th (special) meeting of the Co-ordination Committee of the All India Council for Technical Education, held on January 12, 1963. (Item No. 6).

** Report of the Technical Manpower Assessment Committee, Govt. of India, Ministry of Education, December, 1966.

† Training of Foremen and Supervisors for Mechanical Engineering Industry--Scheme for Sandwich Courses for National Certificate in Mechanical Engineering, Ministry of Education.

envisaged other than the advanced workshop training. This scheme has been implemented so far at 6 centres with an annual admission capacity of 230 students for mechanical engineering courses.

<u>Chemical Operators' Training Scheme</u>:

87. The other sandwich course is for the training of chemical operators and supervisors for chemical industry for which a scheme was formulated in 1959. The duration of the course is 4 years with factory training forming a major part of the third and fourth years of the course. The minimum admission requirement is general education up to the age of 14 years. For those who have completed Matriculation examination, the course is of 3 years' duration with 2,460 institutional hours and 50 weeks of factory training. The course includes a study of humanities and languages, science and mathematics, elementary electrical and mechanical engineering, workshop training and drawing. The speciality training in chemical operations and processes would include 540 hours of instruction in the Institute. The practical training is required to be as broad-based as possible and so designed that a student gains a complete working knowledge of chemical engineering operations, processes, instrumentation and control with emphasis on plant operation and maintenance. By the end of the Third Plan, there were only 3 centres offering these courses with an annual admission capacity for 120 students.

<u>Multitude of patterns of diploma holders</u>:

88. It would be observed that different experiments have been tried in the diploma courses to integrate theoretical instruction with industrial training, either during the course or after the institutional programme. The contents have been ranging between the general broadbased engineering courses for National Certificate - which has been described as diluted version of degree courses-and the specialised technician courses with a modicum of training in a technician speciality, or from the sandwich course covering the whole field of mechanical engineering to the specialised sandwich course for the chemical industry. The duration of the courses also varies from 4 years for the sandwich courses to 2 years for the "technician" courses. The minimum entrance qualifications range from general education upto the age of 14 years for the chemical operators' training to Higher Secondary education for the "technician" courses. This situation of flux with a multitude of diploma course in engineering and technology has, in no small measure, confused the industry about the qualitative level of the diploma holders, passing out of the polytechnics.

At the same time, it cannot be said that any of these courses has been sufficiently oriented towards the real needs of an expanding industry or towards developing technology.

Lack of Involvement by Industry:

89. This is partly because there has not been sufficient involvement of industry in the formulation or implementation of these programmes. The progress of the practical training of diploma holders and graduates is an instance in point. * There are at present only 3,000 places offered for such training as against a combined outturn of 15,000 graduates and diploma holders in mechanical and electrical engineering branches alone. Another probable reason is that all the technician training courses are institution-based, industry being associated as and when necessary for the inplant training. One of the consequences of this lack of mutual exchange between educational institutions and industry has been the imbalance between the real needs of an industry and the educational and training attainments of diploma holders. On the one hand, modern industrial units require specialists for their various departments with intensive knowledge and study in relatively narrow specialities under the major branches of engineering, for example, a machineshop technician. The educational courses, on the other hand, offer a broad-based course covering, for instance, for a mechanical engineering diploma holder, not only the various specialities of the chosen branch of study but also the theory and practice, including drawing exercises wherever necessary, of civil and electrical engineering branches as well. This imbalance together with limitations of organising practical training in industries had tended to minimise the utility of the present diploma courses from the point of view of the needs of the industry. Whatever may be said of the technician/engineer ratio in Indian industry, it conceals qualitative deficiencies in both categories and more so in the technician category.

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* In view of the unsatisfactory position, the All India Council for Technical Education recommended the setting up of an Expert Committee "to examine the entire question of practical training of graduates and diploma holders and formulate a detailed scheme for the organisation of apprenticeship in industry". The Committee is yet to submit its Report. (Proceedings of the 16th meeting held on December 8, 1963, para 60).

Training Programmes of Industry for Technician Jobs:

90. An emerging trend of the industries organising special training programmes for meeting their demand for technicians may be cited here. In the case of the iron and steel industry, a scheme for training operatives for production shops has been started under TISCO and the Hindustan Steel*. The objective of the schemes is to train science graduates for senior positions on the operation side of production departments. The course comprises of an initial period of general training followed by specialised training. The probationers are given specific position training and opportunities on-the-job "to develop proper attitude and to acquire skills and knowledge on the job by actual work experience and assisted by existing operation personnel". The TISCO scheme is of 3-year duration and the Hindustan Steel Scheme is of 18-month duration.

91. Similarly a few mechanical engineering industries in and around Calcutta have organised sandwich courses for mechanical engineering technicians in association with the Calcutta Technical School. The course provides for 3,800 institutional hours and 4,600 hours of training in industry. The minimum admission qualification is Higher Secondary examination pass with suitable subjects. The course provides for 400 hours of instruction and about 1,100 hours of industrial training pertaining to a technician speciality such as production engineering, steel melting, etc.

Need for a Comprehensive Review:

92. It would be relevant here to note that the Education Commission** in its recommendations relating to technician education, has suggested the following tasks:

- an immediate increase in technician training facilities so as to alter the existing "top heavy pyramid of trained manpower";

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* Technical Probationer Scheme for TISCO operation personnel and Senior Operatives Scheme of Hindustan Steel Ltd.

** Report of the Education Commission (1964-66), Govt. of India, Ministry of Education, pp.372-375.

- improvement of the overall ratio of engineers to technicians to 1:2.5 by 1975 and 1:3 or 1:4 by 1986;

- reducing student wastage in these courses which is estimated to range between 35.6 and 50 per cent;

- finding out the clusters of skills/responsibilities for technician specialities;

- making the diploma training more practical by including industrial experience particularly in the last year;

- location of polytechnic institutions near industrial centres rather than on an arbitrary rule of one per district;

- improving training of teachers of polytechnics;

- improving science and mathematics teaching in polytechnics and inclusion of subjects on supervision; and

- introducing sandwich type courses for existing workers in industry to grow to technician positions.

TECHNICIAN TRAINING IN OTHER COUNTRIES

93. An attempt is made here to indicate briefly the salient features of the education and training of engineering technicians in the United States, the USSR, Federal Republic of Germany and the United Kingdom. This is done in relation to the curricular patterns and specialisation of technician courses and the partnership between industry and technical institutions. Before proceeding further, it would be desirable to note the somewhat different historical background in these countries in the field of technical education in general and of technician training in particular. It is well-known that in the U.K., U.S.A. and Germany there has been an age-old tradition of industry being primarily responsible for the training of skilled workers and technicians. This has resulted in the predominance of industry-based as well as part-time programmes, even though the educational system subsequently recognised the need to include courses in technical subjects. Consequently, as many as 60-70 per cent of the technicians in UK and Germany did not go through technical schools meant for the training of technicians.

Further, children in these countries grow up in an atmosphere of science and technology with the use of electrical and electronic gadgets and appliances as a part of their general living. There is also a flexible educational system which gives a liberal choice of subject groups for the students to choose and which also enables the students to complete the courses at a pace determined by the capacity of the students. On the other hand, the USSR pattern, with state ownership of all industries and the highly centralised planning presents a completely different picture. Most of their technicians have completed a programme of formal education and training in a semiprofessional school with orientation towards the specific needs of the local industry. Such differences have tended to influence the choice and details of a system for education and training of technical manpower in these and other countries*, and may be taken note of.

Programmes in USA:

94. There has recently been a clearer appreciation of the role and duties of an engineering technician in USA, as a result of the efforts of the American Society of Engineering Education. The Engineers' Council for Professional Development (ECPD) has also taken over the responsibility for accreditation of engineering technician programme. According to the ECPD, an engineering technology curriculum should include, in addition to a study of basic sciences and socio-humanistic subjects, at least the equivalent of one academic year of technical courses. A high degree of specialisation is favoured for these programmes with field-orientation rather than job-orientation. The foundation for and sufficient emphasis upon technical speciality courses are considered the essence of engineering technology programmes. Curricula of a vocational pattern or any job-oriented specialised pattern would not qualify for accreditation. An examination of the catalogues of a number of well-known technical institutes, offering accredited programmes in engineering technology, indicates that there are about 2,000-2,400 contact hours which are distributed among the subject content as follows:

Content	Per cent
Physical science	18
Mathematics	12

* For instance, according to an OECD survey (1961), 29 per cent of the French and 25 per cent of the Italian technicians were self-taught.

General studies	18
Technical speciality	52

These courses can be availed of as a cooperative educational project so that work experience is suitably combined with the engineering technology programme.

95. The technical institute programme is of two years in duration and the minimum entrance requirements are secondary school graduation, one year of algebra and, in certain States, passing an Engineering and Physical Science Aptitude Test. The technical institutes in Connecticut*, offers this programme on the basis of three 13-week terms per year. At the end of the second term of the first year, the student makes his final choice of curriculum and starts to specialise. Each term, the student receives 28 hours of class-room and laboratory instruction and spends a minimum of another 28-hours of special homework assignments. The curricula provide a thorough background in engineering fundamentals and specialisation in a major field. Among the 143 engineering technology programmes accredited by the ECPD are Civil Technology, Drafting and Design Technology, Fluid Power Engineering Technology, Internal Combustion Engineering Technology, Aeronautical and Space Engineering Technology, Electronic Technology, Mechanical Technology, Tool Technology and Chemical Technology.

Programmes in the USSR:

96. In the USSR** the majority of semi-professional jobs are reserved for persons with formal specialised training and such training is offered in secondary specialised educational establishments. These schools, called "technicums", admit students either after 7-8 years of general education for a 4-year 4 months programme or after the 10 years school for a 2-year 4 months programme. Admission is made

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* Engineering Technicians for Connecticut Industry, Carmelo S. Greco, a paper presented at the Fourth Annual Conference on Technical Education, West Palm Beach, 1962, as reported in the Technical Education News, Vol. XXII No. 2, November, 1962.

** Education and Professional Employment in the USSR, Nicholas de Witt, National Science Foundation, Washington, 1961.

after an entrance examination and 80% of places are reserved for those with employment experience. First priority is given to persons who are assigned to full time study by various enterprises. The aim of instruction in these schools is to train the students in skills and knowledge that will qualify them for employment on the intermediate levels of professional competence. Every semi-professional school graduate must have a skilled worker's qualification in addition to his semi-professional speciality. The training is, therefore, highly intensive in the speciality concerned and in its practical orientation.

97. According to a recent curricular reorganisation, the courses are being modified so as to incorporate employment experience with the programme. Thus, the second year of the 2-year programme or the third and part of the fourth year of the 4-year programme would be offered on a part-time basis. In terms of instructional hours, the technicums in engineering fields offer 42-46 weeks per year with 40 hours of instruction every week. In other words, there are 1500 instruction hours per year. A typical 4-year 4 months programme has thus 6,500 hours distributed among subjects as follows:

Content	Per cent
General academic subjects	25-30
General technical subjects	20-25
Specialised technical subjects	20-25
Applied training	25-30

If the employment experience is also counted, then the duration of a typical 4-year programme, such as, one in tool production, will include 7,330 hours of which 70 per cent are spent on applied specialised courses and the remaining 30 per cent on academic subjects and general technical courses, as shown below:

Structure of Curriculum in Tool Production

	Hours	Per cent
1. General academic (6 subjects)	1,487	20.3
2. General technical (5 subjects)	730	9.9
3. Specialised technical (10 subjects)	1,464	20.0
4. Physical education	245	3.3
5. Applied training	3,402	46.5
	7,328	100.0

98. The technicums in engineering and industrial fields offer as many as 289 technical specialities and each speciality relates to the occupational designation of the future specialist. The training is functionally oriented to suit employment requirements. This is facilitated by the general location of the technicums. Those in engineering and technology are located in cities and industrial centres and the type of industry influences the technical specialities offered in the institutes. Industrial centres with large machine-building plants have technicums for mechanical engineering of various specialisations and so on. The industrial complex provides the technicum with an essential base for applied training and, in return, a technicum trains substantial number of intermediate level specialists for that industrial complex. Teachers for technicums are also recruited from large industrial plants, either on a part-time basis or otherwise.

<u>Programmes in Federal Republic of Germany</u>:

99. The system of training technicians in Germany is essentially practical in nature and maintains close contact with industry*. Technicians are required not only for design but also for work programming and preparation and a host of other activities where these experienced specialists relieve the engineer of many tasks and moderate the acute shortage of engineers. The demand for technicians is increasing because of the increasing rationalisation of the industrial labour with the advent of mechanisation and automation. The following chief areas of employment for technicians in German industry may be noted so as to facilitate a better appreciation of their training programmes:

(a) in design, as designers of machine parts, tools and apparatus, standards technicians, swich-gear technicians, etc.;

(b) in procedure development;

(c) in planning and preparing operations (pre-calculation, time keeping, making time schedule, etc.);

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* <u>The Training of Technicians and Engineers in the Federal Republic of Germany</u>, Erwin Krause, International Labour Review, ILO, Geneva, Vol. LXXXIX, No. 2. Feb., 1964

(d) in production, as managerial assistants, process technicians;

(e) in production control and checking as control technicians, test shop technicians, etc.;

(f) in material testing services and laboratories, as material testing technician, chemical technician, etc.;

(g) in sales and servicing (making tenders, customer service, etc.).

100. The technician specialists in Germany are developed from the category of skilled workers who have broad workshop and plant experience. There is no equivalent of our polytechnic where students are diverted after the high school stage from the general education courses to another educational institution to be trained as a technician. With active interest taken by the Chambers of Industry and Commerce or the Chamber of Handicrafts, there is a variety of apprenticeship schemes leading to professional examinations of these chambers. The accent in all these programmes is on practical training in workshops and study in part-time vocational schools.

101. Vocational schools offer technician training programmes as either a one-year day course or a three-year evening course. The students should have previously done practical work as craftsmen for at least 2 years for the day course and 3 years for the evening course. This would be preceded by 3 to 3½ years of apprenticeship in industry so that the student would have had 5-7 years of practical training before he is admitted to the technician courses. The curricula offered in these schools are specialised but include basic subjects such as mathematics and science and drawing. These basic subjects take up about 67 per cent of the whole programme, i.e. 1,000 hours. There are about 33 specialities offered under these programmes. Most of the vocational schools are linked to trade or engineering schools; there are a few schools under the auspices of the Chamber of Commerce and Industry or Committees of public authorities.

102. The Schools of Engineering* in West Germany are highly developed forms of advanced vocational schools for qualified young people, engaged in manual occupations, after completing their apprenticeship, obtaining the technical school leaving certificate** and having

* Ingeniurschulen.

** Fachschulreife.

the necessary practical experience. Alternatively, students who have taken the junior secondary school certificate*, i.e., corresponding to an age of 16+ years, can also join these courses after the period of apprenticeship or supervised practical training. The course offered in these schools are of 3 years' duration, in 6 semesters, for training as practical or non-graduate engineers. These studies are available in 26 technical specialities, such as, "overground and underground building; surveying; regulation of water supplies and irrigation techniques; machine construction; electrical engineering; manufacturing techniques and industrial engineering; precision techniques; heating and ventilation; ship building; chemistry and textiles"**. The instructional period, totalling 4,500 hours, is distributed by subject content as follows:

Content	Per cent
Basic subjects	30
Technical Speciality	50
Labour and Social subjects and general education	20

The course does not aim at providing narrow specialisation in a given technical speciality, but is reasonably broad-based within the chosen field. This is considered necessary in view of the thorough practical training in industry which has preceded the training in the schools of engineering.†

Programmes in the United Kingdom:

103. Till recently, the pattern in the UK was for industries to recruit their craft apprentices to give them "releases" for attending technical colleges and for taking either the examinations of the City and Guilds of London Institute at the craft and technician levels or the

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* Mittlerereife.

** UNESCO World Survey of Education: III Secondary Education (1961).

† In the OECD Survey on Resources of Scientific and Technical Personnel in the OECD area, the graduates of these schools are taken as qualified engineer "though of less than university degree standard". (Annex. II, pp. 250-51).

examinations for the National Certificates at the ordinary or higher levels. Thus, most of the technician positions were filled by skilled craftsmen with supplementary educational courses. The White Paper on "Better Opportunities in Technical Education", 1961, recognised that the needs of the technician be met not by the courses designed for craftsmen or technologist but by courses designed specifically for technicians. With a view, inter alia, to adapt technical education more closely to the needs of industry, and in particular to meet the urgent need to make more and better provision for technicians, it was proposed to bring about a major reconstruction of system of courses for technicians, craftsmen and operatives. These proposals are being introduced at present in a phased manner. Nevertheless, the salient features of the proposed programmes are indicated in the following paragraphs.

104. There are two major educational programmes open to candidates for becoming technicians, viz., the National Certificate courses and the new technician/technological certificate courses. The former courses are meant for those who have an aptitude for mathematics and could proceed to take Higher National Certificates, recognised as a higher technician qualification. A majority of the students are however expected to take the latter courses which would be designed in relation to the real needs of the industries. Both these programmes would be offered at the technical colleges, mainly on a part-time or sandwich basis. The aptitude of the students for taking up either of the two courses—or in exceptional cases, the craft courses—is to be tested during one-year (part-time) general engineering course for the school leavers at the age of 16+. The duration will be two years for those who leave schools at the age of 15+. This course would comprise of a study of engineering sciences and mathematics, workshop processes and materials (including practical work) and engineering drawing, as examination subjects with the addition of English and General Studies. There would be 240 hours of study per year (part-time) ending with an external examination. Those students who pass in all the 3 subjects at one sitting and obtain 'credit' in mathematics and engineering science are eligible to join the Ist Year of the two-year part-time Ordinary National Certificate course. Those who pass in all the 3 subjects at one sitting can enter the second year of the technician courses while others are eligible to join the first year of the technician courses. In view of the "diagnostic" nature of the General Engineering course, no student is allowed to repeat the course.

105. Technician courses have been designed by the City and Guilds of London Institute in consultation with professional institutions leading to the award of the Institute's certificate. The courses are in three parts, each part forming a definite stage by itself, enabling the students to join technician labour force at a corresponding level. Parts I and II require attendance for not less than 500 hours on a part-time basis and 650 hours on a block release or sandwich basis over a period of two years each. 25 per cent of the time for technical studies is for practical work while in the case of science subjects, 50 per cent of the time is for experimental and demonstration work. Part I of a mechanical technology course, for instance, is intended to give a foundation to students in the principles and practice of engineering, including workshop processes. Provision is made for supplementary training for meeting special needs, if any, such as non-metallic materials, etc. Part II of the course, on the other hand, provides for specialisation in workshop technology or any other special technology such as press tool technology, plastics mould making, plant maintenance and works service, etc. The study of engineering construction and materials relates to the technician speciality selected by the student. In addition, instruction is given in Engineering Science and Mathematics. The C and G Institute examination regulations insist that a student should pass in all the three examination subjects in the same year. Part III of mechanical technology course is open to those who, after completing Part II certificate, have sufficient background of industrial experience so as to qualify for the full Technological Certificate. The course includes not less than 240 hours of advanced study (including appropriate laboratory or practical work) in a subject of choice* and 70 hours of study of a practical subject of applied technology. Similar courses have already been formulated for electrical technicians and telecommunication technicians. It is expected that courses would be prepared for other industries also.

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* The following courses of study have been specially designed by the City and Guilds of London Institute: Advanced production processes; Mechanical engineering design; Jig and tool design; Press tool design and utilisation; Plastics mould design and utilisation; Control systems technology; Plant maintenances and works service; Testing and development; and Mechanical and formal treatment of metals

106. One of the consequences of the White Paper, 1961, already referred to, is the reorganisation of the traditional National Certificate courses at the Ordinary level. Under the revised pattern, the course will be offered as a common O. N. C. for Engineering* instead of the earlier specialisation into mechanical/electrical engineering, etc. The new course provides for broader courses with a greater range of alternative subjects than before. The holders of ONC/OND can pursue their education either by taking Part II certificate of the City and Guilds of London Institute, described in the earlier paragraph or take the Higher National Certificate. The latter certificate is being recognised more as a higher technician qualification and less as an enabling channel for membership of professional bodies, especially when there is a general increase in the number of full-time students for sandwich courses. Thus the holder of an ONC has two possible choices of either specialising intensively in a branch of technology through the City and Guilds Institute courses or qualifying for higher technician positions through the HNC.

107. The ONC courses are of a broad-based character including the study of mathematics, mechanical and electrical engineering sciences and drawing in the first year and mathematics and three more engineering subjects from a wide range of selection**. The choice is made keeping in view the requirements of the Higher National Certificate courses. The duration of the course will be 2 years part-time with 240 hours each year plus additional 90 hours of English and General Studies.

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* The course if taken on a full-time basis, leads to the Ordinary National Diploma (OND). These are awarded jointly by the Ministry of Education and the professional institutions.

** Applied Mechanics; Applied Heat; Workshop technology or instrument technology; electrical engineering A and B; Physics; Mechanics of fluids or aerodynamics; elementary surveying; and materials and structures.

108. The HNC courses are offered as part-time course for 2 years after ONC/OND. Unlike at the Ordinary level where the content of part-time and full-time courses is the same, the HND offers a higher standard of course and is organised on a sandwich pattern of 3 years' duration, as an alternate channel for becoming corporate members of the professional institutions.

CONCLUSIONS ON TECHNICIAN TRAINING PATTERNS ABROAD

109. It is observed that in all the countries studied there is an awareness of the specific role of a technician in the overall engineering employment and attempts are being made to design educational programmes for technicians keeping in view the needs of the industry. A comparison of the relative importance given to broad subject areas in Indian and other technician education/training programmes is given in Table X. In Germany and the U.K., the traditional courses had envisaged a technician as one who had risen from the level of craftsman. In modernising these courses, the trend is therefore to ensure that sufficient instruction is given in general education subjects as well as in engineering and technology. The development of craft skills is not considered necessary except to the extent of specialising in a chosen applied technology. This would explain the "broad-based" courses which are being introduced in the first phase of training technicians. They have also recognised the need for a higher technician or a practical engineer and appropriate courses are being continued at this level, the HNC courses in the UK and the Schools of Engineering in Germany. In contrast, the pattern in the USA reveals greater emphasis on the study of basic sciences and engineering. This is because of the identification of an engineering technician as an expert engaged in application of scientific and engineering knowledge and method and functioning in the range of occupational spectrum closest to the engineer. His education is therefore at the college level and oriented towards major fields of engineering. On the other hand, the semi-professional technician in the USSR is required to have the skills of a craftsman in addition to knowledge of technical speciality partly because his training is planned and organised in relation to the specific and anticipated job positions in an industry*.

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* It is interesting to learn from Nicholas de Witt's "Soviet Education and Professional Employment in the USSR" (National Science Foundation, 1961) that many semi-professional graduates have in fact been employed in skilled worker occupations—as many as 60% in the case of petroleum industry in 1956—not because of higher skill requirements for advancing technology but "largely (due to) the saturation in semi-professional employment demand" (p. 171).

TABLE X

Distribution of Curricular Hours by Broad Subject or Activity Groups for different Technician Courses.

Subject—group	INDIA										U.S.A.		U.S.S.R.		GERMANY			
	3 years Diploma course (1)		2 years Technician course (2)		3 years Chemical Operators' course (3)		4 years Sandwich course (Mechanical) (a)		4 years Sandwich course (Mechanical) (b)		2 years Technical Institute programe (4)		4 yrs. 4 months Technicum course (5)		3 years School of Engineering course (6)		1-year (day) Vocational School course (6)	
	No. of hours	%	No of hours	%	No of hours	%	No. of hours	%	No. of hours	%	No of hours	%	No. of hours	%	No. of hours	%	No of hours	%
1. General academic subjects	576	16.7	...	...	280	10.3	360	18.3	322	10.4	1100	45.8	1990	40.1	900	20.0	}1000	66.7
2. General technical subjects	1746	50.5	1469	48.3	840	31.1	1610	81.7	2047	66.0	200	8.4	820	16.5	1350	30.0		
3. Technician speciality subjects	...	...	268	8.9	540	20.0	...	...	414	13.2	1100	45.8	1250	25.2	}2250	50.0	500	33.3
4. Applied Training (institutional)	1134	32.8	1304	42.8	1040	38.6	...	...	322	10.4	...		900	18.2			...	
Sub-Total	3456	100	3041	100	2700	100	1970	100	3105	100	2400	100	4960	100	4500	100	1500	100
Training in Industry	4400*	...	...		2200		6072*		4608		N A.		1500		...		N.A.	
Total	7856		3041		4900		8042		7713		N.A.		6460		4500		N.A.	

(a) Ministry of Education Scheme, "Sandwich course for National Certificate in Mechanical Engineering, Training of Foremen and Supervisors for mechanical engineering industry", 1957.

(b) Indian Engineering Association Sandwich course for mechanical engineering technicians

*Estimated at 44 hours per week and 50 weeks per year.

N.A. = Not Available.

P. T. O.

Source : (1) Ministry of Education, "National Certificate Course in Civil, Mechanical and Electrical Engineering", 1956.

(2) Ministry of Education, Scheme for "Training of Supervisory personnel : Mechanical Engineering Group :- Machine shop and Tool room technician", 1963.

(3) Ministry of Education, Scheme for "Training of Chemical operators and supervisors for chemical industry", (1959).

(4) American Society for Engineering Education, Final Report of the Evaluation of Technical Institute Education (Technical Education News, Mc Graw Hill Book Co. Inc. New York, Vol. XXII No. 4 April, 1963).

(5) Nicholas De Witt, 'Education and Professional employment in the U.S.S.R.', National Science Foundation, Washington, 1961 (Table III-7 p. 174).

(6) Erwin Krause, "The training of Technicians and Engineers in the Federal Republic of Germany", Internationol Labour Review, Geneva Vol. LXXXIX No 2 February, 1964.

110. While there are differences in the emphasis on the various aspects of the educational programmes particularly between the study of basic sciences and the need for practical training-which are the consequence of the existing patterns in these countries--there is a general consistency in the overall educational and training requirements of technicians in the acknowledgement that an engineering technician should possess; (a) a sound knowledge of the fundamentals of sciences and technology; (b) an adequate training and experience in industry in specific job positions; and (c) a specialised knowledge in one technician speciality within the chosen branch of engineering. The specific number of hours to be devoted to either (a) or (b) above depends upon whether the courses are industry-based or institution-based as well as on the general educational level from which the trainees are drawn and the comparative composition of subject content at that level. In regard to (c), i.e., the need to specialise in a technician speciality, about 1,000-1,200 hours of study and training are allocated uniformly in all these countries, irrespective of the total duration of the course of study.

111. Above all, the survey also supports the conclusion that it would not be desirable to base the planning of technical education programmes on an intra-country comparison and that each country should evolve its own pattern of training and employment of engineering manpower, keeping in view local requirements and conditions.

APPENDIX I

NOTES ON TABLES III, IV AND IX

DEFINITIONS USED IN INDIVIDUAL COUNTRIES FOR IDENTIFYING ENGINEERS AND TECHNICIANS

1. Belgium, Denmark, France, Sweden, Switzerland: data for the countries were taken from the OECD Survey. The survey questionnair defined engineers by their educational qualification, i. e., holder of a degree or equivalent diploma, or possessing training nationally recogn as qualifying him as an engineer. Technicians were also defined by qu lification, i. e., any qualification lower than those stated for engineer bu including at least one year of formal technical education after leaving secondary school. The questionnaire asked for the number of engineer and technicians so defined, regardless of whether they were performin technical tasks. Therefore the employment data submitted by the varic countries should include technical personnel engaged in management an administration, sales services and promotion, market research, etc. Variations were introduced by individual countries, such as:

(a) Denmark - the technician class includes lab technicians; the eng class excludes scientists.

(b) France - the technician class includes all persons peforming the tasks of technicians, regardless of whether their educational qualifications satisfy the definition given in the survey questionnaire.

(c) Switzerland - the engineer class refers to those persons "performing the tasks of engineers or architects, not to the holders of university degrees or equivalent".

2. Ireland: technologists (engineers) and technicians were both defined by the qualifications most frequently possessed by the persons in Ireland, together with a brief description of competence. The figures reported will thus include many persons with the appropriate qualifications who are not performing technical tasks.

3. United Kingdom: engineers are defined as persons holding the qualification of degree holder, holder of diploma in Technology, associate of certain specified educational institutions, or member of

certain specified professional bodies, regardless of whether they are engaged in scientific, engineering, or technological work. One table in the study reports the number of engineers so defined who are actually working as technicians; this number has been deducted from the total number of engineers and scientists. Technicians are defined as those "persons working as technicians and other technical supporting staff, irrespective of the qualification held". The category technical supporting staff includes lab technicians, plant supervisors, research assistants, etc. To compensate for the fact that this category is much broader than engineering technician, scientists are included with engineers in calculations of technician/engineer ratios.

4. United States: both engineers and technicians are defined by qualification, engineers as degree holders or their equivalent, technicians as being schooled in a technical institute or junior college or having received the equivalent in in-service training. All persons of these qualifications are enumerated, whatever their employment situation, providing they are required to use their training in their work. The technician class includes physical science technicians and some biological, agricultural, and medical technicians.

5. Soviet Union: engineers are defined as professionals with higher education; technicians as semi-professionals with specialised secondary education. The definition disregards the job held and function performed. Although the Soviets have enumerated the number of practicals employed in technical positions on an aggregate basis, the industry-by-industry employment figures include only the professionals and semi-professionals.