<講演>

Engineering Training in U. K.

with special reference to

Metal Finishing*

T. J. Takats**

Synopsis

The background and recent developments in the training of professional engineers is examined. The entry requirements to register with the Engineers Registration Board, ERB are specified. The average length of employment in one post as well as the mobility in UK and within EEC is discussed. The training courses to gain registration with ERB with their various routings are described. The employment ratios and job functions of professional engineers are examined.

The training in the metal finishing industries is related to the above.

Background information

The training of engineers is approached various ways in different countries; the term used to described qualifications and positions are even more ambigous, thus creating confusion.

England has a long history of developing along traditional, a practically applied manner the engineers, however with the rapidly increasing output from the recently started Colleges of Advanced Technology, Super Polytechnics and red-brick Universities, the establishment of the Council for National Academic Awards (CNAA) all added to the complications.

The academic qualifications were not automatically accepted by the professional engineering societies and membership of societies or institutions yields no academic acceptance. To gain in industrial acceptance one has to join Engineering Institutions covering one's field of activity. The Engineering Institutions are a traditional establishment in Britain; there are over two dozen senior ones and many additional recent ones.

Technical Colleges and training courses were naturally developed specifically aiming at passing the examination of a particular institute. As courses matured and in general satisfied the requirement of the Institute, the latter accepted the college examinations as qualify for "exemtion for taking the institutes" examination.

This produced a general system, the "National Certificate" system, adopted, accepted and partly supervised by the Institutes. However, each institute developed its own criteria and standards, hence diversion of levels set in.

The establishment of the Council of Engineering Institutions (CEI) was set up to solve this problem and to coordinate levels, criteria and harmonise the development and cooperation of the institutions. The constituent institutions are given in appendix A.

Registration of engineers

In the UK in 1964 a national registration system, the "Engineers' Registration Board", ERB. was set up. Registering with ERB is voluntarily. ERB is administered by CEI, whose Royal Charter now is extended to include not only chartered engineers but also technician engineers and technicians.

Though registering is voluntarily; engineers and technicians will find it more and more difficult to practice their profession if they are not registered with ERB.

The legal qualifications of chartered engineer (C. Eng.), technician engineer (T. Eng. CEI) and technician (Tech. CEI) are obtained by entry in the national register of the Engineers' Registration Board (ERB)

*1976년 5월 21일 춘계 학술강연회에서 강연
**UNESCO Training Adviser, F.I.C. 역임

which is managed by the CEI. Membership of this register is subject to the terms of the Royal Charter granted to the CEI in its present form in 1971.

The criteria for entry in the three categories of the ERB register are as follows:

For chartered engineers (C. Eng)

1. Minimum age: 25

2. A pass mark in the examination in applied science held by the CEI in accordance with the council's regulations or a pass in any other university examination or test accepted by the CEI as being of at least equivalent level (the University level of the examinations and tests held or accepted by the CEI is not less than that of the Degree in Engineering).

3. Practical training in the engineering profession, or functions which make it possible to acquire such training, meeting the practical training criteria established by the CEI member institution and complying with the general principles adopted by the CEI.

4. At least two year's experience in a post considered by the CEI member institution to entail professional responsibility, provided that the total sum of the period of this professional experience and the period of practical training referred to above is not less than three years.

For technician engineers (T. Eng. CEI)

1. Minimun age: 23

2. Academic qualifications at a level at least equivalent to that of the Ordinary National Certificate, or the City and Guilds Part 11/Final Technician's Certificate, and approved by the Office of the ERB and the CEI (unless otherwise decided by the Office and the CEI).

3. Five years minimum practical training and experience in the engineering profession, two of which must have been spent on practical training, both experience and training to be recognized by the Office of the ERB and the CEI.

For technicians (Tech. CEI)

1. Minimum age: 21

2. Academic qualifications at a level at least equivalent to that of the Ordinary National Certificate or the City and Guilds Part 11/Final Technicians' Certificate, and approved by the Office of the ERB and the CEI (unless otherwise decidedby the Office and the CEI).

3. A minimum of three years' practical training and experience in the technical field, two years of which should have been spent on practical training recognized by the Office of the ERB and the CEI.

Mobility of Engineers

The previous patterns of employment of spending one's life time predominantly in the local industry with one or two employers are diminishing. Mobility of menpower not only in the region, but inter-regional are required as the employment possibilities gravitate.

The local employers in an industrial zone will give preference to locally trained engineers, as they would know how well his training been done. With the ERB certificate the employers are ensured, at least, a certain minimum level.

In the UK the average stay in one job is between three to four years. As expected the yonng professionals move more frequently (once a year under 25 years of age.), while the 40 years or over group will retain a post for an average period of about five years.

By sector, the mobility is more frequent in mechanical three years) and electronics engineering (just over three years) while instrumentation, electrical and aerospace engineers stay an average of four year in one post. (For full detail see Ref. 2).

On joining the European Economic Community even more complications arose. The "Continental system" of national engineering registration is mainly based on academic diploma, while the British System is based on a very searching and difficult professional examination, as well as good, solid practical experience.

At times, British Engineers lack academic qualifications from Universities, as their continental counterparts nearly all possess, nonetheless, if they are registered with the ERB to any of the CEI's categories, they will be accepted in Europe.

With the ups and downs of technical higher educational institutes and their adjustments and re-adjustment of qualifying levels, with the introduction of new cou-

rses the industrialist had a difficult time to assess with any certainity the value of different qualifications. The writer of these lines once suggested to drawn up a "wine list", rating the "crop" not only by the place but by the year also.

Whilst the establishment and maintenance of such a comperative study of qualified engineers would had been a lucrative operation for some, industrialist need to rely on more direct and less subjective information.

The European Federation of National Associations of Engineers, FEANI, formed as early as 1951 has concerned itself with the problem; it had given lead to the national authorities in setting up the: "European Register of Higher Technical Professions" in 1965. This has been amended in 1970 and '71.

The FEANI register has two basic groups, A and B. People, who by virtue of their academic and/or professional attainment do belong in their respective countries to the top or "cream" of the professionals, and are registered as such, will automatically belong to group A, which has sub-groups. People with unfinished secondary education and good, practice oriented further training, specialised education or vocational training to a high level may apply to register in group B.

To gain professional acceptance within EEC, one should register with FEANI. Such a certificate will provide prospective employers at least a basic assurance that the candidate has a certain professional engineering background.

On setting up the EEC, due consideration has been given to the matter of harmonising technical education and establishing comparative standards and co-valencies in the EEC Draft Directive No. 2.

The definitions of EEC Draft Directive No 2 and that of the FEANI are given below (for more details see Ref. 1) in their three categories of:-

a) Conception, C
b) Liaison, L and
c) Execution, E.

Category C, roughly covering "conception engineers". These are technologists who are accustomed to think in abstract terms, to take a synthetic view of events which are not obviously linked together and to demonstrate a sufficient degree of creativity; they also have, of course, a sufficient degree of practical knowledge in order to be realistic and not limithemselves to theoretical speculations.

C-1: Definition in Article 1 of the EEC Draft Directive No. 2

A Diploma awarded on successful completion of a full course of studies of, at least, four years taken at university in the discipline corresponding to the activity concerned.

A Certificate attesting the actual performance of the activities concerned for at least two years after the award of the diploma.

C-2: Definition in section As of the FEANI European Register of Higher Technical Professions

Qualified engineers from schools providing a complete scientific and technological education at university level.

Admission to these schools is at the level of the examination giving access to university education.

Category L, roughly covering 'liaison enginers or srnior technicians'. These are nechnologists who provide the link between 'conception engineers' (whose predominant competence is theory) and 'execution technicians' (whose predominant competence is practice). The "liaison engineers or senior technicians" are, therefore, capable of understanding abstractions and of translating them into practical language, thus forming the essential bridge between the other two equally essential categories.

L-1: Definition in Article 2 of the EEC Draft Directive No. 2

A diploma awarded on successful completion of a full course of studies of at least three years at a higher technical institution in the field of study corresponding to the activity concerned.

This course should be preceded by the successful completion of at least twelve years' education, including studies and practical training.

A certificate attesting the actual performance of the activities concerned for at least two years after passing the final examination.

L-2: Definition in the FEANI European Register of Higher Technical Professions

L-2. 1: Definition in section Ab of the register: Graduates of schools that provide a less extensive but more practical scientific and technical education lasting at least three years. Admission to these schools is at the same level as university entrance.

L-2. 2: Definition in section Ba of the register: Graduates of a higher technical school providing a course of at least three years' duration, and who have obtained a minimum of three years' practical experience before, during or after the course.

Admission to these schools is at a lower level than the examination giving access to university, and the studies are generally mainly in specialized technical and scientific subjects with a practical bias.

Category E, roughly covering 'execution technicians'. These are technologists who carry out and are responsible for the execution of projects initially conceived by the 'conception engineers' and then adapted to the practical realities of industry by 'liaison engineers or senior technicians'.

E-1. Definition in Article 3 of the EEC Draft Directive No. 2:

A certificate attesting that the holder has completed at least thirteen years education in a State-recognized technical school, including as a final stage a complete course of at least two years' full-time technological education in the subjects corresponding to the activity concerned.

A Certificate attesting the actual performance of the activities concerned for at least two years after completion of the technological education.

E-2: Definition in the FEANI European Register of Higher Technical Professions:

For the time being there is no definition.

Interesting to compare the definitions in the above three categories with the definitions under criteria for entry to the ERB for (C. Eng), (T. Eng. CEI) and (Techn. CEI) respectively as given in the previous chapter.

Training of professional engineers

There are many different ways to reach the level of a chartered engineer; this great flexibility is the main strengh of the British system. The main routes are:

1) Having obtained the minimum univesity entrance requirements one may enter a university taking a full time three years degree course or a four year industry college integrated sandwich course.

2) Having completed the science/technical secondary education by obtaining three Ordinary level and two Advanced-level in relevant subjects-one enters a polytechnic and attends a four year sandwitch course to gain a diploma.

3) With four Ordinary level and one Advanced level subjects one may enter a polytechnic or a technical college to follow a 3 years sandwich course to gain a Higher National Diploma, HND. After receiving the HND he or she will have to complete a course of at least one year full-time study for the second part of the CEI examination.

4) Having completed the secondary technical education with only four or five Ordinary level in relevant subjects and having completed a two years ONC or OND course one can either take a part-time day/evening two years course leading to a Higher National Certificate, HNC, or entering various courses at technical colleges he successfully completes the part one of one of the CEI examination. After both cases, as in 3) above, he must complete at least one year fulltime study for the second part of the CEI examination.

5) After having left secondary school with only three Ordinarly level subjects and studied for three years part time at further colleges of education for a City and Guilds Certificate followed by a year part-time study for the City and Guilds Full Technoligical Certificate. After that he may study for the part one of the CEI's examination. Having obtained a pass (or execution) in the part one, he may follow on course equivalent to at least a one year full time course for the CEI part two examination

Obviously the last route is a very lengthy one; nonetheless, it provides opportunity to "slow starters" or people who set out on a trade or skill training and later decided to gain higher and higher professional status. In fact, this opportunity for most criates a healty situation, as people with predominatly part time study, practical experience background can eventually compete with scientists from the strongest academic background.

The above routes, together with the near minimum time required to complete and the various levels of qualifications are shown in **Fig. 1.** In **Fig. 1** for the routes 4 & 5 the entry with four ordinary (O) levels or with three respectively is set at 18 years of age. In fact these may be obtained at the minimum school

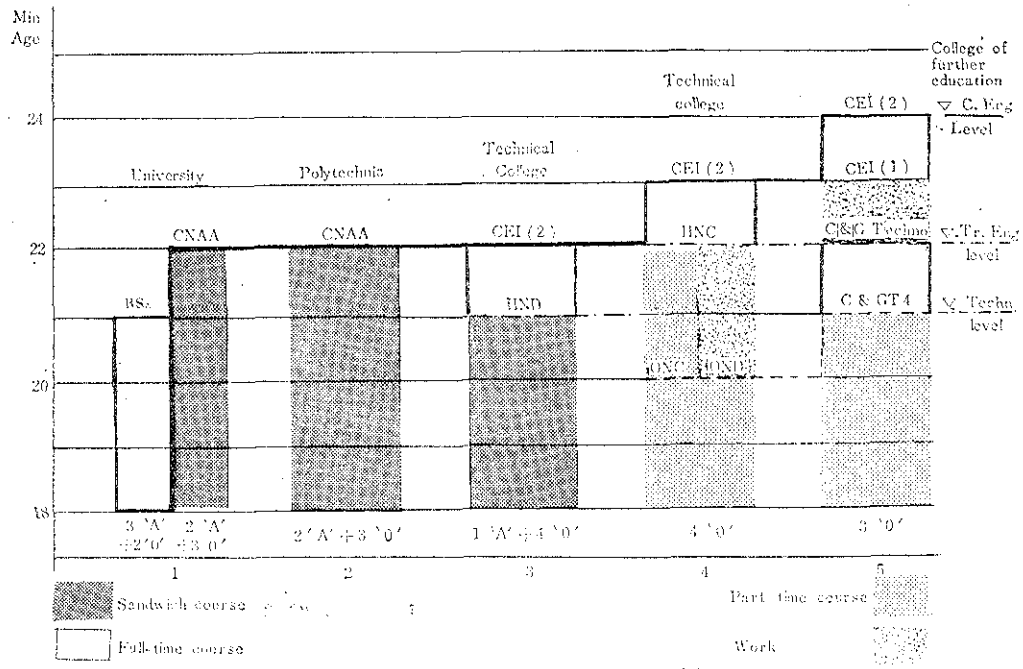

Fig. 1 Training courses leading to CEI qualifications

leaving age of 16.

It is significant that over two third of professional engineers arrived via routes 1 or 2, some 18% via routes 3 & 4 and less than 5% via route 5. (For full details see Ref. 2)

It is interesting to note the tendencies; the combined routes 1 & 2 (university or equivalent) routes 3 & 4 (technical college, HNC/HND+CEI part 2) and route 5 (City & Guilds courses+CEI part 2 exam.) are analysed by age groups in fig. 2.

In the under 30 age group 87% chose route 1 or 2 just over 10% the route 3 or 4.

In the 30—49 age group, the current bulk of professional engineers, 66% arrived by routes 1 or 2, 22% by routes 3 or 4 and the rest by route 5 or other (foreign equivalents) routes.

In the 50 or over age group only 41% came via routes 1 or 2, 17% via route 4 and the rest via route 5 or other ways.

There is an increasing tendency for professional engineers to take higher degrees, in the under 39 years group 10% has higher degrees, in the 30—49 age group some 5~6% and in the 50 or over group only 2%.

About 1% of the total employed manpower in UK are professional engineers and 1/2% are scientists. The percentage of employment in various field is shown in Fig. 3.

The employment ratios of professional engineers to technicians in the electronics/electrical and aerospace industries is high at 1:3 or so, where large efforts are put into research development and design RD & D, and in the large volume production type activities, like vehicle production, machinery and the like, for one professional engineer there are 5 to 8 technicians (For full details see references 3 and 5).

Professional engineers will spend over half their time

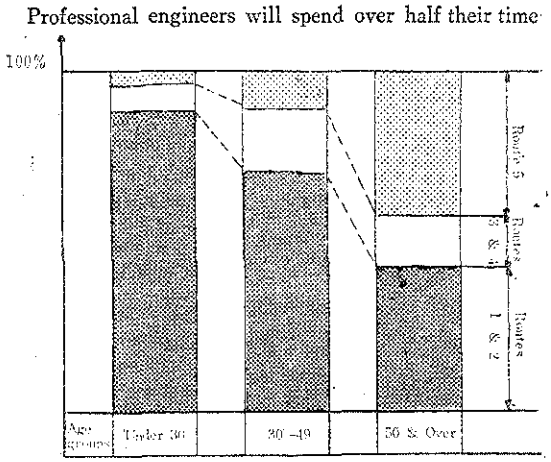

Fig. 2 Tendency in the choice of training of professional engineers

in written or verbal communication with others, a quarter of their time in technical services and design, about one eights of their time is used for management and supervision and the rest in production organization, sales or other activities.

The written communication involve technical reports, test reports, publications, specifications, quotations, procedures or instruction manuals, layout plans, work instructions, technical illustrations, diagrammes and graphs.

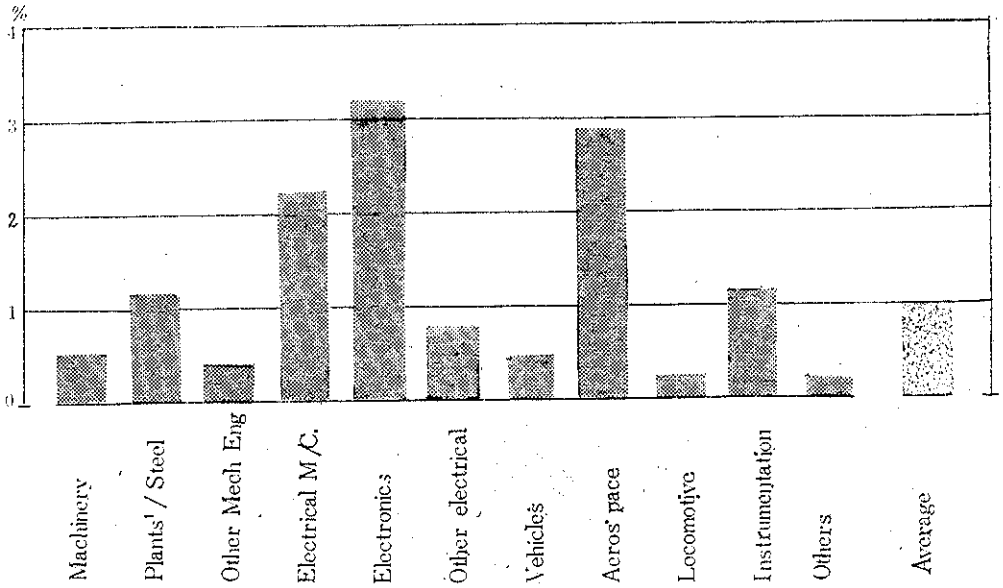

Fig. 3 Distribution percentage of professional engineers in industrial sectors (source: Ref. 2)

Training in the metal finishing industries

The amalgamated training requirements for this interdisiplinary subject were organized on the basis of the long experience of the Institute of Metal Finish, IMF. The basic disiplines involved are metallurgy and or metallography, applied chemical engineering further to some extent mechanical and electrical engineering.

The usual route followed by a professional engineer in the field of metal finish is to graduate in one of the above bafic disiplines and then specialise by a post gradute course or experience.

While the International Standard Classification of Occupations, ISCO, classifies only the skilled or craft occupations like 7.00-30 "Metal Cleaner", 7.28-30 "Other metal platers and coaters" and 8.35-20, "Electroplater", in the professional strata, the IMF has very strict control on the criteria of entry qualifications.

IMF awards the following certificates:

(a) Technicians certificates on the satisfactory completion of a course and/or passing the Institutes examination. The preparatory courses for such an examination will be conducted in "Further Colleges of Education" or in Technical Colleges and probably will, follow a City and Guild or London Institute (CGLI) curriculum.

(b) The Advanced Technical Certificate, which requires not only academic training but also two years of relevant experience in industry.

In the higher levels of professional engineering IMF is not authorized to issue certificates; however, at that point the grade of membership will give the indication of the level attained.

(i) The "Licenciateship of IMF" is the junior grade; those who qualified by the certificate of (a) or (b) above will gain that designation.

Their corresponding level will be Technician, (Techn-CEI) and Technician Engineer, (T. Eng. -CEI) respectively, On the FEANI classification they will belong to the "Execution" and "Liaison" group respectivey.

(ii) The "Associate" of IMF will have graduated from a university or would have satisfied the election

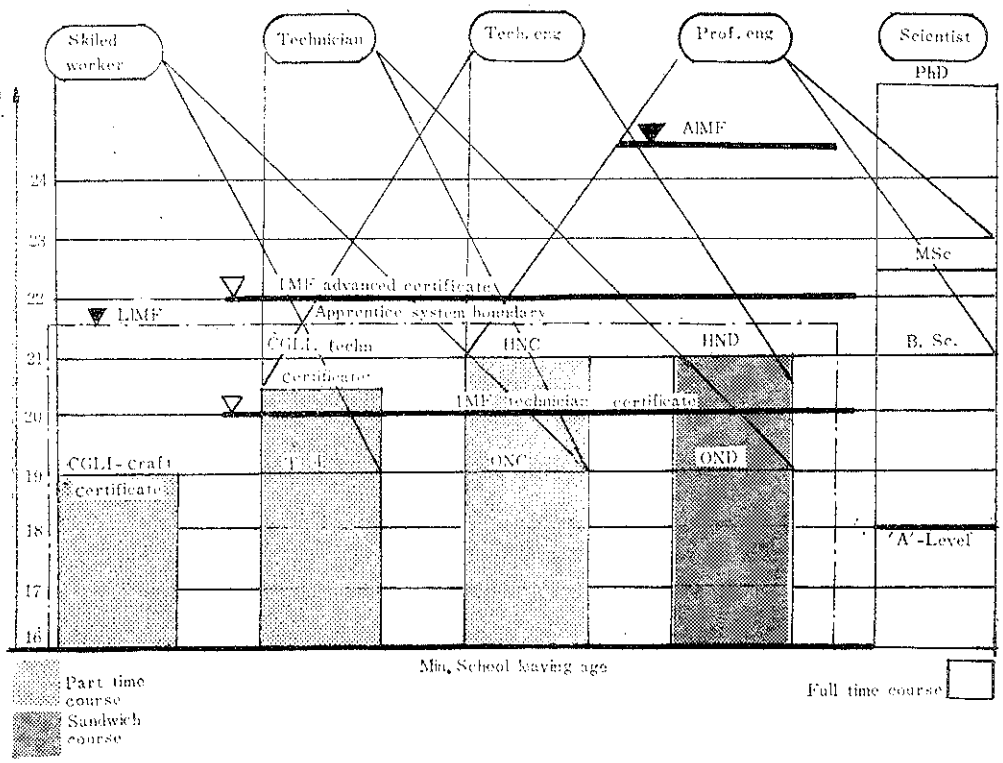

Fig. 4 Technical training in the metal finishing fields

board that he has completed courses corresponding to or equivalent to a relevant university qualification together with three years of practical industrial or training experience in a position of resopnsibility.

By responsible position it is understood that the candidate would have been in charge of several persons of at least one level lower qualifide and would have been involved in affecting engineering decisions.

They would correspound to the C-Eng. level of CEI and will be considered as professional engineers. From FEANI'S point of veew, they most probably be in the "Conception" group, though some might in fact be actively involved in the "Liaison", which includes technical sales, process specifications and the like.

(iii) The "Member" of IMF and "Fellow" of IMF are grades of distingtions. After several years of work as "Associates" in the relevant industry they would have contributed to the advancement of the science and or technology and have attained professional eminence in their field.

The educational routes leading routes leading to various certificates and grades of membership of IMF are shown in **Fig. 4.**

In UK the apprenticeship is of long tradition and it is currently being coordinated by the Engineering Industry Training Board, EITB, which is a branch of the Industrial Training Board, ITB. An act of parliament in 1966 established ITB to work in collaboration with the Department of Education and Science (In UK the Department refers to "Ministry" in this instant) and with CEI for the training of skilled and professional manpower, and to assure that the industrial training practiced by various companies will meet a certain, minimum criteria.

Most technicians and engineering technicians (senior technicians) would have completed such an apprenticeship, which is of three and a half years duration on the average. During apprentice training the aspirants would have attended college choosing the routes 3 or 4 on **Fig. 1** or route 5. After completion of apprentice training the candidates may apply to be considered for "Licenciateship" of IMF.

People following routes 1 or 2, as shown in **Fig. 1** will have passed to start at the junior level of "Licenciateship" and after three years of relevant experience in responsible position may apply to be considered for "Associate" membership.

It is to be noted, however, that people who followed the less academic routes do have a very good chance to reach the "Associate" grade, provided that they have fulfilled a position of responsibility for sufficienttime and have demonstrated their professional competence.

The differentiation between various levels may be done by considering their job-functions, as given below.

Technician

He would perform the duties of a plating shop foreman, or first level supervisor in a small plating shop where he may also be a worker or second level supervisor in a larger shop. He sheuld be capable of planning and supervising all normal types of plating and finishing work without help or direct supervision. He should be capable of estimating, costing and planning the work of the shop. He should be fully capable of understanding specifications and organizing the necessary quality control tests. He should also be capable of determining the reasons for faulty processing and taking the correct remedical action, further he ensures that safety regulations are carried out and safe working methods are used.

He may also be employed as a research/development assistant. In this case he would normally be continuing his training (possibly part time) to become a technician engineer.

Technician Engineer

He would perform the duties of a third level supervisor either as the manager of the finishing department of a large or medium company, or as the manager of a specialist finishing company. He would not have a worker function. In addition to the previously described capabilities of technicians he should be capable of carrying out functions of a manager. He should be capable of specifying finishes and if necessary drawing up specifications. He must be able to draw up shop safety regulations. He should be capable of contributing to the design of products which have to be finished to ensure that the finishing processes can be carried out in the simplest, cheapest and most effective way. He should be capable of performing the function of adviser on material to ensure that the product with not fail in operation due to corrosion. He will do forward planning; future work loading, future equipment requirements, budgeting and layout of facilities. He may also be employed as a research develoment worker.

Professional Engineer

Will perform the duties of manager or superintendent of a medium or large company. In addition to the functions adscribed to the technician engineer, he may undertake research and development of new technologies or usage of new materials. He will specify tests and test procedures for the control of quality and make investigtaions for the assurang or quality.

He will diagnose problems and offer solutions, considering not only the application of scientific knowledge but also the cost effectiveness and the economic viability.

He will undertake the development of new products and procedures.

He will direct the planning, costing and running of all kinds of operations related to metal finishing. He might work as a seientist or university lecturer, dedicating his knowledge and experience to the advancement of the mentl finishing industry and scientific knowledge.

REFERENCES

1) Standards for Engineering Qualifications. A comperative study in eighteen European countries. The Unesco Press—1975
2) Professional engineers, scientists & technologiests in the engineering industry. EITB Research Report No. 4
3) Developments in Vocational Guidance, Training & Instruction. T. J. Takats 1976, (Islamabad)
4) The Training of Technician Engineers

ITB Booklet No. 9

5) The Technician in Engineering
EITB Research Repoet No. 1

6) The Training of Technicians
ITB Booklet No. 14.

APPENDIX A

Member institutions of the
COUNCIL OF ENGINEERING INSTITUTIONS
are:—

Royal Aeronautical Society
Institution of Chemical Engineers
Institution of Civil Engineers
Institution of Electrical Engineers
Institution of Electronic and Radio Engineers
The Institute of Fuel
Institution of Gas Engineers
Institute of Marine Engineers
Institution of Mechanical Engineers
Institution of Mining Engineers
Institution of Mining and Metallurgy
Institution of Municipal Engineers
Royal Institution of Naval Architects
Institution of Production Engineers
Institution of Struotural Engineers.

강연자 소개

Mr. T. J. TAKATS, 4 years of age obtained hir technological training i Budapest before moving to England in 1956. Afte working as a designer fo four years in indusiry, took a full-time course to obtain an honours degree in mechanical engineering from the university of London.

Following some experience in consul tancy andprod uction engineering, begun his career as a technical educator.

For seven years tought at polytechnics in Londen as a senior lecturer. During this time undertook part time research for a Master of Philosophy degree. Since late 1969 he has worked with United Nations as an Expert in technical training. Currently he is with the Korea Fine Instruments center as the UNESCO Technical Training Adviser.

Mr. Takats is a professional engineer with C. Eng., MIMechE, MSE, FIQA, member FEANI (group A) and member ASME.