## OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

## DISCLAIMER



## FAIR USE POLICY



## CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org


United Nations Industrial Development Organization

Distr.
RESTRICTED
ID/WG.7/6
31 October 1967
ENGLISH

AD HOC MEETING ON IN-PLANT TRAINING
Vienna, 13-18 November 1967



# THE IN-PLANT TRAINING OF ENGINEERS IN THE UNITED STATES

Prepared for the
Management and Training Section
Centre for Industrial Development

by

Philip R. Kelly
Consultant

---

The views and opinions expressed in this paper are those of the consultant and do not necessarily reflect the views of the Secretariat of UNIDO

id.67-042

# INTRODUCTION

This report is based on discussions with engineers, engineering managers, personnel executives, college and university faculty members, college placement officers, engineering association executives and editors of engineering journals.

The report focuses on the in-plant training of newly graduated engineers and is organized in the following manner:

I. A Preface, setting forth the general conditions and some basic problems influencing the training of young engineers;

II. A Main Section, outlining the specific programs of selected major corporations;

III. A Summary, including a review of some additional problems faced by foreign trainees; and

IV. An Addenda, with some special notes and acknowledgments.

V. An Appendix, including certain exhibits not included in the body of the report.

## I - PREFACE

This portion of the report will attempt to provide a broad perspective of the factors which influence the development of young engineers in the United States today. First, an overview of trends in the United States which have strongly affected the engineering profession.

The journals, conferences, and programs of engineering educators and associations in the United States indicate lively concern and controversy over the following:

1. Current and impending shortages of engineering personnel;

2. The threatened obsolescence of many engineers who graduated from college prior to 1955;

3. The growing impact of federal government's vast financial support of research and education, plus the impact of governmental space and defense programs;

4. The selection, recruitment, retention and development of engineers in general; and

5. The optimization of engineering talent at all levels.

## The Engineering Shortage

The shortage of engineers in the United States is currently estimated at 100,000 men and estimates of future shortages run as high as 500,000 by 1975. This shortage has significant impact on the selection, recruitment, training and early status of the new college graduate in the engineering field.

## Problems of Obsolescence

The knowledge of the Graduate Engineer today is estimated to have a useful life of about ten years; that is, half of what he knows will be obsolete in a decade. Or, to put it another way, half of what he will need to know in 1973 is not available to him today. This, of course, is linked to the well-known "knowledge explosion". It is estimated that our entire storage bank of scientific knowledge will double between 1960 and 1970. (One major U. S. Corporation -- R. C. A. -- recently estimated that eighty per cent of its sales today were from products unknown ten years ago. DuPont forecasts that at least sixty per cent of its 1975 sales revenue will be from products now in their introductory stages or still to be invented.)

Curriculum

One of the liveliest and most volatile controversies in the United States is centered around the "ideal" engineering curriculum. The dynamics in this field, of course, stem from the major scientific and technological developments since the start of World War II. In 1955, the Guinter Report of the American Society for Engineering Education recommended two major curricular changes:

1. To increase the portion of time devoted to the basic sciences, mathematics and the engineering sciences to roughly half the four-year undergraduate program, and

2. To increase the proportion of time devoted to humanistic-social studies to as much as the equivalent of one year of study. The result of these changes has been the emergence of a general field of engineering science and as Dr. Andrew Schultz, Dean of the College of Engineering at Cornell University has said, "The almost complete displacement from the early years of courses in technology, skill and the art of engineering."

As Dr. Schultz pointed out:

> "Another important influence has been the impact of Federal action on the demand for engineers. Close to half of the engineers of the nation are employed directly or indirectly on Federally sponsored activities; obviously the most important, in terms of numbers, are major defense and space projects."

> "It is thus clear that (1) the types of technology with which engineers are expected to become familiar and use effectively has proliferated greatly, (2) the level of sophistication demanded by some of these technologies has risen considerably, and (3) the cost and impact of poor engineering decisions has greatly increased. It should be expected, therefore, that the engineering educational process might be influenced by these significant developments."[1]

To summarize, new standards of quality and the increased scope of engineering education plus the accelerated pace of change makes "obsolescence" a key concern, even for the new graduate.

Effects of Shortages on Engineering Recruitment and Training

The shortage of U. S. engineering talent has produced intense competition between both private corporations and government for the available talent. Recruiting, which used to be a minor function, is now one of the most important functions in U. S. management. The intense and constant search and competition for talent has produced a proliferation of staff and methods to attract the new engineering graduate. Since the success of any training program depends to a large extent on the caliber and attitudes of the trainees, it is relevant here to examine some of these new trends and their impact on engineering attitudes, which in turn affect company training design.

[1] "Creating Second Sources of Engineering Manpower", published by The Institute of Electrical and Electronics Engineers, Inc., U.S.A., 1966, p. 15.

First and most importantly, the abundance of career opportunities for engineering graduates naturally makes the graduate more and more selective and critical of his first job choice. (Many men, of course, have had some job experience and indeed have moved toward permanent employment with a company via summer or cooperative programs. However, it is not the intent of this report to focus on this aspect of in-plant training.)

Another growing staff activity in the United States is the role of the Placement Counselor in universities and colleges. The executives working in this field attempt to serve as analysts and links between the needs of industry and graduates' career goals. Some idea of the intensity of this recruiting effort may be gained from examining the activities at Lehigh University, a leading engineering institution. With approximately 350 engineering graduates in 1967, Placement Office statistics showed that over 2,200 job opportunity notices were posted by over 500 companies.

To speed the recruiting interview process, companies are going beyond normal recruiting literature to plant visits, help on housing and educational subsidies, etc. Both recruiting offices ir corporations and university placement offices are considering the use of films and

video tape. Under this process, video tapes of the graduate would be made available to the recruiter; the recruiting companies also arrange to show video tapes or films of their corporate sites, facilities and other relevant data.

Another leap forward has been made in the past several years with the installation of the GRAD system. This is a computerized information retrieval system for college placement officers and employers, sponsored and administered by the College Placement Council. Under this system, any alumnus with a four-year degree from an accredited college or university can have his experience, specifications and the type of position he is seeking made available to a vast national network of employers.

Engineering Mobility

In today's booming job market career possibilities for young engineers are indeed dazzling. In addition to heavy recruitment, the young graduate is assailed with a constant barrage of enticing mail and large newspaper display ads. Also, the spectacular growth of executive recruiting firms has greatly facilitated the mobility of executive and professional personnel of all types.

For all of these reasons, plus the fact that "training programs" have often carried with them a connotation of low status or lack of financial incentives, many companies have been moving away from the longer, slower, conventional orientation and training program for the new graduate. Much of this change stems from the fact that the superior young graduate, faced with many job opportunities, is no longer content with jobs which do not have meaning or challenge, or which do not present growth and reward potential.

## Selection - The Starting Point for Good Training

A competent personnel recruiting group recognizes the need for a diversified mixture of young men. It is relevent to note that most companies recognize that high grades are not the only index to engineering success. Those companies which are most successful in selecting, recruiting and developing young engineers are those which probe deeply into the man's interests, attitudes, aspirations and values, rather than relying merely on his academic report.

It must be emphasized that the companies in the United States are highly concerned about the turnover rate in the first three to five years of employment. This is a period when the new graduate seems most restless and many changes in training programs are linked directly to this fact.

With these general remarks noted, we may now move to the main body of the report.

## II. IN-PLANT TRAINING OF ENGINEERS IN THE UNITED STATES-1967

### Introduction

As every experienced training officer knows, providing an effective transition for any young college graduate entails much more than a neat schedule of rotating work assignments. He knows that there are two key problem areas:

1. The overall psychological, social and emotional problems of the post-adolescent in the United States; and

2. Divergent views of reality and some potential hostility between "Trainee" and "Trainer".

With reference to No. 1 above, we have too often neglected to deal with the whole man and his problems of transition and adjustment. Engineers, in particular, may push aside such ideas and concentrate on planning and scheduling the "ideal" technical program. Yet, if the other, more personal problems of transition are ignored, they may greatly impede the entire learning process.

With reference to No. 2 above, there exists, as always, a considerable gap between the views and sophistication of personnel executives and other top managers, and the attitudes of lower and middle managers. Unfortunately, many of these supervisors, with little understanding of themselves or the new graduate, may have hostile reactions toward the young graduate.

Dr. Edgar H. Schein, writing in the Harvard Business Review,[1] listed the following common viewpoints:

1. A college graduote is aver-ambitious and unrealistic in his expectatians regording the possibilities af advoncement; he tends to think that his educotion has given him some kind of speciol privilege ta mave up fast in the arganizotion.

2. The college graduote is too theoreticol, idealistic and naive ta be given important initial assignments; he must first be "broken in", and shown how the theories tought in college may foil to fit practical facts in industry.

3. The college graduate is too immature and inexperienced to be given much responsibility. He would be likely to fail.

4. The college graduate is too security-conscious and too unwilling to take risks.

5. The college graduate is unwilling to recognize the difference between having a good idea and the process af selling that idea; he is unskilled in communication and unwilling to wark hard to get his ideos across.

6. The college graduate is a potentially highly useful resource for new ideas, but he must be broken in before this resource becomes available to the organization.

Dr. Schein adds that the college graduate himself may realize his own naivete and immaturity; however, from what he has heard

[1]Edgar H. Schein, How To Break in the College Graduate, Harvard Business Review, Nov.-Dec., 1964.

from the recruiters, he is likely to view the arganizatian as sympathetic to his plight. However, in actual fact, some personnel in companies often view these characteristics as problems which may be exorcised in a direct and unsympathetic manner.

In explaring the students' views, Dr. Schein lists some of the factors identified as important by students in surveys of their attitudes toward their new enviranment. Listed in order of importance, they are:

Very Important:

Opportunity for advancement.
Social status and prestige.
Responsibility.
Opportunities ta use special aptitudes and educational background.
Challenge and adventure.
Opportunity to be creative and original.
High Salary.

Less important:

A stable and secure future.
A chance to exercise leadership.
Opportunity to work with people rather than things.
Freedom from supervision.
Opportunity ta be helpful ta athers.

Prof. Schein, however, points out that listings of this type classify only the surface characteristics of what people want in their jobs. He says: "In interviewing students, I have noted deeper issues which are

not so easily represented, yet which are psychologically more important for the person." He placed these issues in five categories:

> 1. Will the job provide an opportunity to test myself, to find out whether I can really do a job? Will I be able to stand the pressures of working on the real things which matter? How will I deal with my own anxieties and tensions? Will I like the job and how good will I be at it?
>
> 2. Will I be considered worthwhile? Will my contribution be appreciated? Will I be given a chance to show what i can do? Will I be given any real responsibility?
>
> 3. Will I be able to maintain my integrity and individuality? Will I be able to lead a balanced life, to have a family and to pursue private interests?
>
> 4. Will I learn and grow? Will the job not only provide an opportunity to use my present talents and background, but will it also afford me an opportunity to learn new things and develop new talents?
>
> 5. Will the organization in which I work meet my ideals of the rational business organization described in economics and business courses? Will the organization be utilizing, or at least be receptive to utilizing, new techniques of production, marketing and the like? Will it be dynamic and exciting? Will it enhance my self-image to be a member of the organization?

All of these questions reveal the hopes and fears of the post-adolescent; for the first time he is going to test himself and find out how good he is in the adult world. Naturally, this brings many social and emotional problems with it. These must be dealt with if the technical and other phases of the training are to be optimized.

## Three Outstanding Company Programs

The following pages offer a review of three company programs which have successfully dealt with in-plant training. All vary somewhat and each was designed, or grew from, its own special corporate environment. The companies involved are:

1. The American Telephone and Telegraph Company
2. E. I. DuPont de Nemours & Company
3. Bethlehem Steel Company

### American Telephone and Telegraph Program[1]

A. T. & T.'s program began in 1958 with research which was prompted by dissatisfaction with their past training programs. The key weaknesses of the old programs were designated as:

1. Undemanding work assignments;
2. Over-emphasis on craft activities vs managerial activities;
3. Poor on-the-job supervision;
4. Faulty evaluation, often based on non-managerial assignments or personality characteristics;
5. Misunderstanding by trainees of their responsibility for self-development.

Under the new program, the trainee is not only assigned to a high level supervisor -- this supervisor is carefully selected, trained and held responsible for:

1. Preparing challenging assignments;
2. Creating an atmosphere conducive to growth;
3. Determining future promotion potential.

[1] For a more complete description of this program, See Appendix, Exhibit "A"

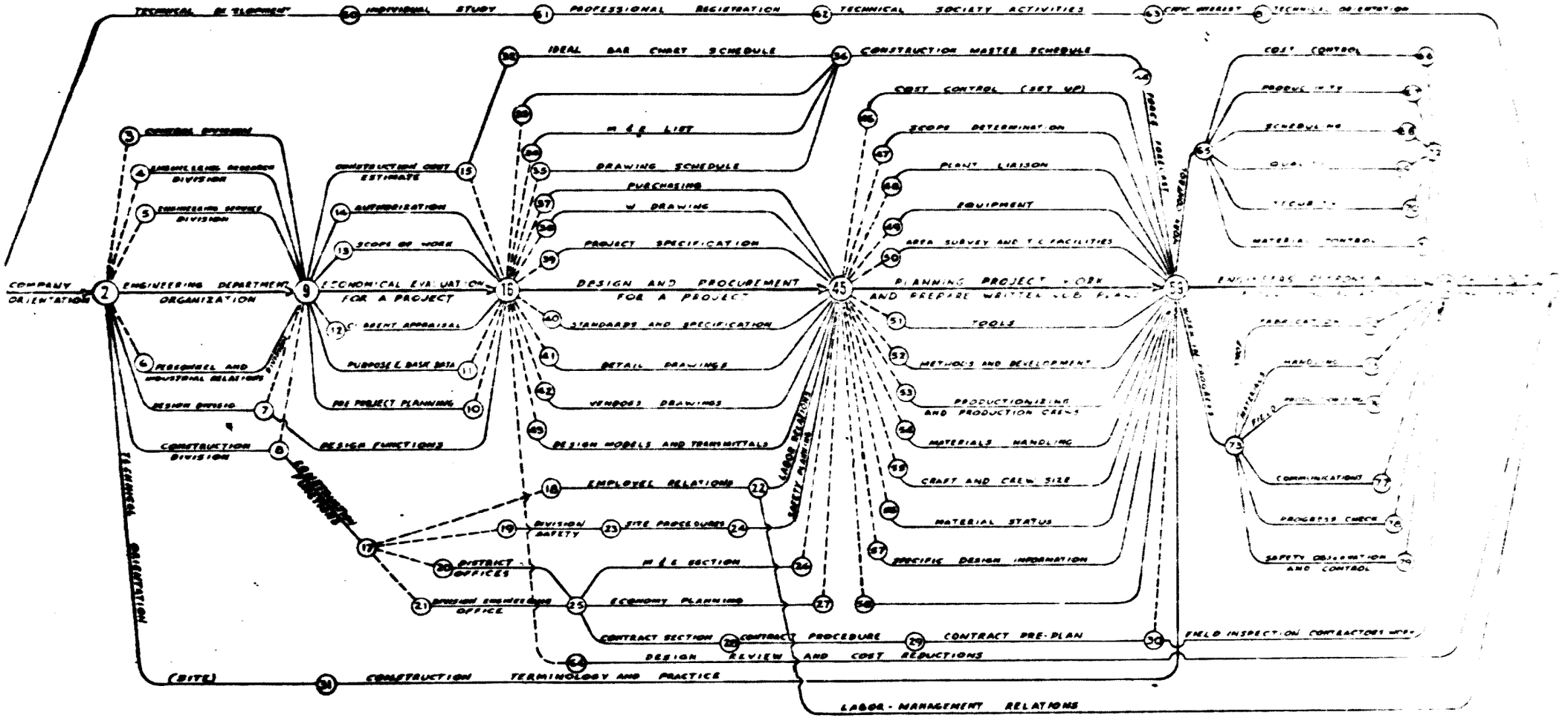
Note that this is not a "soft" program, but is based on the assumption that the best method of challenging a new man is through immediate immersion in a specific job. A. T. & T.'s tendency is to put a man on a tough assignment. As one executive said, "Many of these assignments we know are tougher than we would normally give to a new graduate. However, many of the men have shown an outstanding ability to expand their capabilities quickly." Such an approach, of course, accepts the idea that a good number of the men will not measure up and will perhaps leave the company, but A. T. & T. believes that a certain amount of turnover is inevitable. The most important point is that the project supervisors are involved in a program on "Developing Young Managers", and are also involved in bi-monthly follow-up meetings.

Another key point is a training program for the trainees on "Your Development Planning." Both supervisory and trainee programs use sensitivity training concepts. At the end of a year, successful trainees go into classroom training at the end of these experiences, rather than at the beginning. These are special three-month programs and again are designed to speed the development of the new engineer.

The overall administration of each program is under a Program Director, who again is carefully selected and trained for two weeks in his responsibilities.

# AREA ENGINEER DEVELOPMENT

## CONSTRUCTION DIVISION



DuPont Program [1]

A somewhat similar approach is undertaken at DuPont where again men are hired for specific jobs. In the Construction Department, men are given assignments as fledgling area engineers and they are carefully groomed and tested on specific assignments. These men work with one Senior Advisor and a Manual of Responsibilities. The Manual lists not only specific resource people, but a number of goals for the new man to master in this particular phase of his development. Most importantly again, the new man is given a really challenging assignment and definite responsibility of a supervisory type.

DuPont has also made two outstanding steps in development of an engineering "learning path" and simulation program. The young engineer is placed in an eight-day workshop which tests his knowledge and interpretation of his responsibilities in his new job. As a part of this exercise, these men are given a typical engineering project. Each man must plan, coordinate and go through all of the activities essential to making the project move along effectively. His efforts are critiqued by seasoned engineers and managers in an effort to speed up his comprehension of the interaction between the engineering activity, administrative, supervisory and management skills.

[1] For more specific data on DuPont program, See Appendix, Exhibit "B"

The DuPont program, in summary, attempts to provide "an honest atmosphere in which the young engineer can determine his own role". Again, this includes challenging assignments, training, and feedback at all stages.

The Bethlehem Steel Loop Course

The Bethlehem Steel Company is the United States' second largest steel company, with over one hundred thousand employees. Both in operations and management, engineers have played an extremely important role. The Loop course gets its name from the fact that the men go "around the loop" of the Bethlehem Steel system in their orientation and training phase. This program was initiated in 1922 and as proof of its success, the current Chairman of Bethlehem Steel was a "Looper" as well as many other top-level executives and plant managers. What are some of the ingredients in the Bethlehem Steel Loop Course?

1. Continuous top management recognition, participation, surveillance and support.

2. Integration of manpower planning, selection, recruitment and placement.

3. Specific and meaningful job assignments with a minimum of corporate classes.

4. Continued and constant coaching, feed-back and follow-up.

5. Real incentives and rewards for the men who successfully complete this program.

Examining these activities point by point, we are provided with some explanation for the success of this particular program:

Top Management Participation and Support

As the new "Looper" goes through his orientation and training phases, he comes face to face, both formally and informally, with former "Loopers". It is part of Bethlehem Steel's tradition that the "Loopers" constitute an elite corps and former "Loopers" take both an interest and pleasure in helping the new man develop. This high status is recognized and accepted with very little hostility at all levels.

Manpower Planning

The first step in the selection process lies in the area of company manpower planning. Representatives of the Personnel Department are in charge of administering the "Loop" program, and work closely with other company executives to analyze future manpower needs. One of the strengths of the Bethlehem Steel Loop Course is that they will not hire a man unless they have a prospect of an "exempt salary" opening within two years. This means that Loopers coming in have definite prospects of promotion to first-level supervision or other jobs in engineering of the

"exempt" category. (Such benefits are sizeable, and include higher salaries, up to six weeks vacation, considerable insurance and the right to join some of the outstanding social clubs and country clubs which are available to exempt personnel only.) In other words, Bethlehem Steel builds a high promotion incentive into the very basis of their program, relatively early.

Recruiting and Selection

In the interface between the personnel group and the operating managers, who state their requirements and promotion opportunities, a great deal of knowledge is accumulated in the terms of the specific type of job for which the man is being recruited. The personal qualifications and specific training essential for each specific job are very clearly delineated. The existence of such clear specifications makes it much more probable that recruiters will be able to select appropriate candidates.

The Loop program has proved effective in cutting down turnover. A Bethlehem Steel executive said that "since 1922 over 4,000 men have gone through our Loop course, and over 58% of these men are still employed." This impressive record is another evidence of the success of this particular program.

Men selected for the program must be United States citizens and have a degree from an accredited four-year college. Bethlehem Steel insists that the men have graduated no earlier than one year prior to the start of the Loop course (exceptions are made for military service.)

Basic Program

The Loop course begins each year in July; only one course is conducted each year. The three basic phases are: (1) basic orientation; (2) specialized training; (3) on-the-job training.

In the basic orientation, which lasts five weeks, the Loopers are taken through the headquarters organization, meeting with officials and managers at every level. Motion pictures and guided trips throughout the system are part of this particular process. The men are required at each phase to submit written answers to questionnaires to insure that the material covered is being absorbed. This is the beginning of the constant feed-back which is one of the major strengths of the program.

Intensive Training

At the end of his five-week orientation program, the Looper is placed in the plant or division he has chosen to enter, and here he goes deeper into the particular operation. This phase may last from three to twelve months. He is always working closely with supervisors and managers

who are required to submit periodic reports -- usually every three months -- to headquarters. The important point about these reports is that they do not disappear into a file, but are carefully routed upwards and in every case receive no lower than Vice-Presidential attention.

At the end of this experience, Bethlehem Steel management then begins to pinpoint a specific job for the trainee. Corporate Personnel Office keeps closely in touch, via both quarterly reports and personal visits. Throughout his job assignments for the first five years, the Looper is given a very careful annual review by top management to check his progress. Again, managers at every level know that they will be held accountable to top management for the way in which they handle, work with and develop the young engineer.

The importance of this particular phase cannot be emphasized too highly. In many cases and in many companies, employees and trainees are seen as sort of "second-class citizens" who are to be broken in by the older hands. In some of these companies, the attitudes may seem to the new man to be much more like collegiate "hazing" rather than an intelligent introduction into a new and challenging work environment. Bethlehem Steel, with its over 50 years of experience, and its continued top management interest, has produced a high-quality program which does an outstanding

job on an informal basis, largely because there is no doubt in anybody's mind that:

1. This is an important program;
2. These Loop trainees are future managers; and
3. That their development is one of the great resources and assets which can and will help the company to continue to grow.

## III. SUMMARY

By examining the foregoing portion of this report, it will be seen that the planning and successful implementation of a good in-plant training program for engineers has many facets. First and most important is its complexity, which goes far beyond merely setting up a series of rotational job assignments.

There can be no formula for an ideal program, for each must be tailored to the specific organization. However, here is a listing of components which should be considered:

1. A realistic appraisal by the employer of the psychological, social and emotional problems inherant in the post-adolescent trainee.

2. Top management support, participation and surveillance.

3. Adequate budget, staff and other resources.

4. Administration by a high-status person or group within the organization.

5. Manpower planning and analysis of real job opportunities.

6. Realistic communication between the plant managers and other supervisors who will work with the trainees and the personnel people and recruiters who will bring them into the organization.

7. Constant and meaningful communication and relationships between the corporation and college placement offices.

8. Depth interviewing and other techniques which will give the selection process added validity and the chance to fit the man to the organization.

9. An integrative approach which would include meaningful job experiences, related training of a technical nature, and of an administrative nature as well.

10. Attempts through the use of simulation and other modern training techniques to help the new employee more quickly understand the realities of the organization world. This might include special training, for example, in inter-personal activities, perhaps using the techniques now available through sensitivity training.

11. Perhaps most important, an attempt to train and educate in depth the personnel who will be handling the trainee during his formative years.

12. Constant open communication and feed-back, both from the trainee and the people working with him, on all aspects of his progress or problems. In short, a much more complete system of feed-back and analysis than is now covered in many rather perfunctory reports.

13. The designation of some one person, preferably another trainee, who can act as sort of an informal coach and interpreter of the new world for the new employee. It may be advisable here to have the man designated also undergo some special training and education as to the types of problems he is most apt to encounter.

14. Finally, management should be aware not only of the factors listed above, but also of all of the components which we now know are essential in the management of professional personnel. The new concepts in organizational structure, supervision, leadership, group dynamics and management by objectives -- particularly where the objectives are set by the trainee -- are essential if we are to really give the new man an opportunity to make his test and develop himself in his new role.

Some Thoughts on Foreign Trainees

The problems inherent in the in-plant training and transition for the United States graduate are often compounded in the foreign trainee. Selection is the basic problem. No trainee can be selected merely an academic standing; his character, personality, maturity and motivation are perhaps more important.

Obviously, the ability to speak, read and understand the host country's language is essential. But men of an excessively regressive nature, however brilliant and however skilled they may be in lingual ability, will not be able to adapt and get the most out of their training time. Various attempts have been made to explore the problems of acculturation to new countries. It seems logical that any program which involves bringing a large number of men for a considerable length of time into a new country should spend considerable time working with the men before they get into the new country, and particularly the first several weeks or month afterwards, attempting to make clear the norms of the particular work culture. Here, again, training and education can speed the process of acculturation, and thus help optimize the new trainees' learning potential.

To summarize and conclude, design and implementation of in-plant training for foreign trainees is an extremely complex task. It includes not only those problems common to the U. S. graduate, but other problems of a linguistic and cultural nature. Management always needs to consider how best to deal with the whole man, rather than a technical segment of his being.

# IV. ADDENDA

## Acknowledgments

The consultant is indebted to the following organizations for a variety of discussions, data and materials:

Industry

Air Products Company
A. T. & T. Company
Armstrong Cork Company
Bethlehem Steel Company
Communications Satellite Corporation
Deere and Company
DuPont Corporation
Ford Motor Company
General Electric Corporation
I. B. M. Corporation
McKinsey and Company
Pennsylvania Power and Light Company
Port of New York Authority
Union Oil Company
Western Electric Company
Westinghouse Electric Corporation

Colleges, Universities and Associations

Allentown College of St. Francis de Sales
Harvard University
Lafayette College
Lehigh University
Massachusetts Institute of Technology
Pace College

College Placement Council, Inc.

Engineering Associations, Societies and Periodicals

The engineering profession in the United States is fortunate in having outstanding leadership and help in its associations, societies and periodicals.

Attention is called, for example, to the portfolio, "Professional Guide for Your Engineering Careet," produced for the young engineer by the Engineers' Council for Professional Development. This portfolio contains selected pamphlets, readings and a personal career planning analysis form for the young engineer.

Among the more prominent groups are:

The National Academy of Engineering
Engineers Joint Council
Engineers' Council for Professional Development
American Society for Engineering Education

# V. APPENDIX

No report on the education and training of engineers in the United States would be complete without some reference to the long experience of The General Electric Corporation and The Westinghouse Electric Corporation.

While it was not possible to review these programs in depth, an outline of the approach taken by these two companies is shown by Exhibits "C" and "D" in this appendix.

## EXHIBITS

Exhibit "A" - A. T. & T. Program

Exhibit "B" - E. I. DuPont de Nemours Area Engineer Program

Exhibit "C" - General Electric - "Education for Technical Management"

Exhibit "D" - Westinghouse - "Engineering Careers in Westinghouse"

EXHIBIT "A"

SUMMARY VIEW -- A. T. & T. PROGRAM

By 1958, accumulated disappointment in the overall results of current initial training pragrams, supported by Management Pragress Study findings, made clear the need ta find a better way to handle the development of college recruits and others of high potential and ta do it in less time. In addition, there was a need for a higher yield of people from these sources who had the ability to compete for and win district and higher level positions. As a result of this concern five companies, together with the Persannel Research Staff of the American Company, undertook the develapment of a plan to accomplish these results. This work was started in October, 1958, and became known as the initial Management Development Research Project.

From this project came the IMDP or initial Management Development Pragram which officially started in 1959.

Briefly, the pragram has the following objectives:

To identify and accelerate the development of recently hired callege graduates who have the potential for operating effectively at the district levei.

To increase the proportion of college graduates hired who earn district level responsibilities.

To attract the more competent college graduates to the Bell System.

The program has the following principal features:

A. Assignment of the Recruit to a District Level Supervisor

The individual with the most significant role in determining the success or failure af the development process is that of the immediate supervisor. These young men are hired to fill the future requirements af the System for district level and above management positians. Therefore, it follows that they should be evaluated as nearly as possible in their careers on their potential to reach objective levels in a reasonable period of time. The man best equipped by experience and responsibility to do this should be the trainee's boss. In order to give him the maximum opportunity to be tested and evaluated, the young man reports directly to a district level supervisor.

It has been found that the district man selected to fill this important role should have most, if not all, of the following qualifications:

- He should be willing to try new ideas.
- He should have a good record of past achievements.
- He should have demonstrated the ability to delegate effectively.
- He should be firm in his beliefs, yet not inflexible.
- He should be known for his high work standards.
- He should have demonstrated the ability to effectively develop his subordinates
- He should have confidence in his own ability.
- He should have demonstrated courage by his willingness to take risks when required.

The district man is made responsible and accountable for:

(1) preparing challenging assignments; (2) creating an atmosphere which will be conducive to manogerial growth and development; (3) determining by the end of the first year whether or not the young man appears to have the potential to handle district level responsibilities effectively within five years. If he does not, it is to his and the company's best interests that he seek employment elsewhere. In order that the district man be given every opportunity to make the correct decision, here are some factors that should be taken into consideration:

- He should not be assigned more than one recruit.
- He should have the freedom to adjust his organization as he feels necessary in order to provide proper assignments.
- The boss should be allowed the full year; i.e., reassignments of the boss or trainee should be avoided. If the boss is relocated, consideration should be given to moving the trainee with him.

## B. Training for the District Man

A training course entitled "Developing Young Managers" has been prepared to assist the district man in understanding his responsibilities. It has the following objectives:

1. To pass along what is known -- from social science research and business research -- about the process and problems of growth and development of young people. This is to provide a background of knowledge for the bosses which should make their efforts more effective.

2. To guide and accustom the bosses to think about the kinds of assignments which will facilitate the growth in management ability of their college-recruit subordinates. This is the most important objective of the five days. The establishment of guiding principles at this time is essential to success of the program.

3. To focus attention an the problems surrounding the process of appraisal of managerial ability.

It is important that it be given prior to the assignment of the recruits to their bosses.

The course utilizes a minimum of lecturing and a high proportion of time is spent on "stimulated discussian". This means that attention is focused on a problem by a case or other set of circumstances introduced by the leader

C. Troining of the Recruits

In addition to the course offered to the district men, a course has been prepared to assist the young men in making the transition from an academic atmosphere into the business world. This course is entitled "Your Development Plonning" and has the following objectives:

1. To acquaint participants with the general plan and purpose of the Initial Management Development Program.

2. To initiate the pracess of teaching the recently hired college graduate to assume primary responsibility for his own growth and development in manogerial ability.

3. To increase the college recruit's self-awareness.

4. To help newly hired graduates take the first steps in planning a personal develapment program.

These objectives are not taken up in any sequence, since they are interdependent to a great extent. However, the responsibility for self-development is established on the first day. Techniques used include role play, developmental discussion, self-administered questionnaires, and group problems.

It is considered important that the young men receive this training as promptly as possible after being placed on the payroll.

D. The Program Director

The Program Director is the overall administrator of the program. He may be assigned to the area or company headquarters staff, and is considered the "key" man in the overall success or failure of the program. Some of his functions and responsibilities include:

- Assisting the departments in the selection of district bosses.
- Keeping management informed about the program - its purpose, progress and problems.
- Working closely with the College Recruiting Coordinator to insure mutual success in attainment of common objectives.
- Conducting the training course for district men.
- Conducting the training course for the recruits.
- Conducting bimonthly follow-up meetings for the district bosses.
- Conducting bimonthly follow-up meetings for the trainees.
- Conducting individual interviews with district men in the intervening months. (More often, if necessary.)
- Conducting individual interviews with the trainess in the intervening months. (More often, if necessary.)
- Assisting district bosses in making meaningful, challenging assignments.
- Assisting the departments in obtaining effective utilization of high-potential manpower. (Post IMDP assignments.)
- Compiling records of assignments, progress and evaluations.

The number of college students hired varies greatly by company and area. Experience has shown that from 12 to 15 trainess constitute a full load for a Director. When more men have been assigned, it has been found difficult to conduct the program properly. Conversely, where the number of men hired is substantially less than twelve, the Director has time to devote to other duties.

The Personnel Relations staff of the American Company conducts periodic two-week training conferences for prospective Program Directors in the Initial Management Development Program. These conferences have the following objectives:

- Produce a fundamental understanding of the principles and philosophies of the Initial Management Development Program.
- By actual participation, introduce the conferees to the one-week training courses in which they will lead the district men and young managers.
- Develop conference leadership skills.
- Study some of the problems of growth and development of managers.
- Develop an understanding of the problems that may be encountered and the methods employed in the administration of the program.

E. Follow-up Program

The value and need for effective follow-up as a means of attaining objectives is well established. This program relies heavily on follow-up, and consists of two principal methods:

1. Follow-up Meetings

The follow-up meetings are conducted bimonthly for the district men as a group, and bimonthly for the trainees as a group. Usually the Director will schedule the meetings in alternate months. During the course of the year, there will normally be five meetings of each group. The general purpose of the boss meetings is to review assignments and evaluate performance. In addition, the

bosses have an opportunity to discuss future plans for their trainee as the year progresses. The Director uses these meetings as a vehicle by which the bosses are encouraged to examine critically their own and each other's assignments so that improvements may be made.

The meetings held for the young managers also offer an opportunity to exchange experiences. Here, however, the men examine their experiences from the standpoint of what growth opportunities were offered, and how well these opportunities were utilized. In addition, they may examine and discuss pertinent articles and case material relating to the development of managerial abilities.

2. Individual Interviews.

The program of individual interviews is arranged so that there will be conducted during the intervening months between meetings. In this way the Director will see each boss and each trainee at least every month. This may be more often if any of the interested parties so desire. The role of the Director in these interviews, and indeed in the whole program, is not to give instruction or be the authority on behavior, but rather to be a "sounding board". His objective at all times should be to strengthen the boss-trainee relationship, not substitute for it.

In the interviews with the district men, the Director consults with them in the strengthening and implementation of their assignment programs. In the interviews with the trainees, he discusses their opportunities and encourages them to maximize their own personal managerial growth.

EXHIBIT "B"

E. I. DU PONT DE NEMOURS & CO., INC.
ENGINEERING DEPARTMENT

CONSTRUCTION DIVISION

## AREA ENGINEER DEVELOPMENT PROGRAM

The Division was faced with a significant increase in work load which would require hiring many new field engineers. The market for young engineers was highly competitive. To meet our commitments we would have to consider not only current college graduates, but also engineers with various degrees of experience, military and industrial. Each will be faced with the need to adjust to the organization in which they work and to become productive in terms of "work performance" in their assignment.

If there is o correlation between the time an employee adjusts to an organization and the time he becomes productive in that organization, then it reasonably concludes that the sooner an "honest" adjustment is made, the greater the potential for earlier productivity.

Looking at our organization we observed these facts. Field construction sites are located in many parts of the country. Each site has its own management staff headed by a field site manager. Many sites have projects lasting anywhere from a year or so up to many years. In terms of getting the job done, safety, quality, economy and schedule are elements most frequently emphasized. Plants must be built to function on time. They must be built within cost limits and they must be built safely. The engineers who build them must "go where the construction is". All field sites basically observe the same standard of administrative procedures, but frequently have variations as diverse as the people who administer them.

Yet in any case, when a man is assigned to a site, he must adjust and produce. This is the scene into which a new engineer steps.

Two inherent problems traditionally seem to complicate effective efforts to train people at construction sites. They are:

1. Geographical location and size. Sites are widely separated. Job diversity and the varying number of engineers on a site create different site attitudes toward training and ability to train.

2. Heavy pressure to "get the job built" supercedes the time needed for personnel development.

Essentially, our new problems are:

1. The rapid expansion itself, bringing many new people.

2. Competition with other firms for the services of these new men even after they are hired.

3. An increased urgency to get the new men into productive work.

We recognized first that both the traditional "no time for development" and this newer urgency expressed a commendable concern for production, but unfortunately, not the same degree of concern for people -- at least beyond the immediate production need.

As a result of this atmosphere, our purpose was to reaffirm the principle that "people properly developed will get you your production and get it better" and beyond that, "people properly developed are more likely to become your career employees". Now we had to define "proper development".

Our definition stated in its simplest terms was:

- the engineer comes to understand fully the <u>essential</u> responsibilities of the job in which he is hired.

- he sees clearly the nature of his authority.

- he understands what is meant by company policy.

- he recognizes the relationship between his goals and the division's goals, and thus can define his career possibilities.

What could be done to expedite these understandings?

The development of new engineers seemed to fall into two phases:

1. That which is learned at the field site. (This includes facts, figures, simple job functions.)

2. That which is learned better away from the site. (The honest perspective of the engineer with regard to his function and stature in the organization.)

Thus we developed the program into two phases: That part to occur at the field site for which field site management is primarily responsible, and that which is to occur elsewhere for which division management is primarily responsible. The first phase orients the new engineer and prepares him for the second. The two do not conflict.

Before our development of this program could continue, two questions needed answering:

1. What does a new engineer need to know?

2. How could we organize this information?

Logically, for our purpose, answers to these questions could best be obtained from our company ranks.

Assembling this information, a "learning path" was formulated in the form of a "diagram". The "learning path" represented that sequence through which an engineer may learn both the general and essential make-up of his job on the site. A "site guide" was developed on the basis of this sequence. The guide and the diagram were given each new engineer to follow over the first three months of his employment.

Division management concurred that no part of the new engineer's assignment would supersede his completion of the "site guide".

To be effective, the "site guide" must be used by the engineer himself, since presumably he is the one most interested in learning his job. The engineer's immediate supervision and site management must be ready to give help when the engineer subscribes for it.

This three-month initial development period at the site for all new engineers is essentially administered by site management. Site management must see that the development takes precedence over routine work, and yet the development must be involved in the engineer's actual work assignment. This gives the engineer a perspective of his work in relation to the "diagram" and "site guide".

The engineer's immediate supervision must be available to supply the most help and direction. Other assistance requested by the engineer must be provided by staff members and site meetings. During this three-month period, support, help, and direction are available, but the responsibility rests with the engineer himself.

The second phase of development convened at a location neutral to any site (motel). Twelve to fourteen engineers meet for a period of six and one-half working days.

The objective now becomes one of the engineer bringing into focus:

- His job responsibilities.
- The nature of his "authority".
- His understanding of "company policy".
- His relationship to the company.
- His recognition of career opportunity.

The responsibility, as in the first phase, remains with the engineer himself, yet is now shared by division management.

The first day begins with the introduction of the trainer and assistant field site manager. (Each session is attended by an assistant field site manager. This category of manager was selected for his age proximity to the engineer; his knowledge of site functions; and for the reciprocal impact that the engineer and the manager can have on each other relative to individual development.)

The trainer simply states that "The session is to help you get a better understanding of your job, your company and your career opportunities."

"The session is essentially yours, to contribute and to conclude what you think appropriate."

Trainer suggests that a useful place to begin might be to "discuss what your responsibilities are".

He states that chart pad is there for them to use.

He then remains silent ...

Typical reactions are:

Void of silence (must be filled) . . .

One engineer breaks silence . . . Discussion builds slowly at first, then more rapidly.

Someone volunteers to chart responsibilities.

May try to arrange in order of importance. (Usually frustrating.)

Someone suggests that "We really don't know each other very well. Why don't we describe a little about our backgrounds and our sites?"

They do . . .

The trainer uses this type of approach to have the group continue to look at other questions about themselves in relation to their job and to reach their own conclusions. They discuss and involve themselves in:

"Problems in their assignment"

"Where their authority extends"

"What are the engineer's chief responsibilities?"

The first team assignment follows. They are divided into two teams with identical assignments: "Prepare a written description of what a job plan is" (purposely ambiguous.) No leaders are appointed, no further instructions are given by the trainer, except a time limit of one hour. At the hour's end, again with no instructions, each spokesman in turn gives the team's report.

After the assignment is cimpleted, responses from engineers to trainer's question of "How did you reach conclusions the way you did?" included:

"Assignment didn't make much sense."

"We had to work out what we thought was a satisfactory answer."

"I'm beginning to think this assignment was just as much to start us thinking as it was to get an 'answer'".

These are some of the responses the trainer found to the question, "What do you feel in general that you have gotten out of today's session?"

"We are getting to know each other. I like to find out who my competition is."

"All sites do things a little differently."

"But, at the same time, I'm surprised to see how much alike they are."

"All engineers have essentially the same problems -- which is a comfort to know."

After the engineers made other similar conclusions on their own, it was not rare to find comments such as "I guess you meant it when you said what we get out of this is up to us!"

The trainer then shows slides of a predetermined job area. The assistant field site manager assigns a job plan for the two teams to write (again, ambiguous on purpose). There is a seven-hour time limit. All necessary prints, maps, Standards, etc., are available at a place in the room. The assistant field site manager is available as a consultant "at all site levels" provided questions are specific and are appropriately directed.

The completed job plan is to be written on a chart pad. The engineers return to their teams with no further instructions.

The second day starts with the engineers continuing the assignment. Late in the day both teams present their job plans as they see fit. Both teams challenge the relative merits of each other's plans.

The trainer asks, "How was your team able to organize and get this rather large job done?" Response from group member - "At first we floundered around. Then we recognized someone had to break down the tasks and get to work on a systematic basis."

The trainer asks, "With such superficial instructions, how were you able to formulate the plan?" Group comments include:

> "Each one of us recognized he was responsible to contribute."
>
> "Each of us would probably have written the plan differently, but we had to pool our thoughts here."
>
> "The best thoughts seemed to get accepted."

The trainer commented, "You seem to be suggesting a relationship to your job." Group comments:

> "Definitely. This is the only way really to get a job done. We talk about not having enough authority. This is our authority."
>
> "As engineers we get paid to take an ambiguous situation, make sense out of it -- and get the work done."

Each day of the following four will be spent with one division representative. These four management representatives are specialists on safety, economy planning, cost, and employee and labor relations. The representative and group discuss division policy, review job plans, and analyze typical situations. The group, as teams and individuals, work out solutions to the problems, ask questions, and react as they feel necessary. The representatives are not role playing. They respond as themselves. Some tell the engineers those things which they feel the engineers must do to succeed. Others present the engineers with that which is fact (standards, specific policy, chain of command, etc.) and let the engineers determine for themselves those things which a person must do to succeed. The situation is an honest one. These are the people the engineers must deal with -- directly or indirectly. As a group continues, the "myster" of upper level management tends to disappear. The often referred to "THEY" becomes specific people.

The last half-day is spent with the engineers making any analogies, conclusions, or determinations they feel they want to express.

Comments include:

> "In almost everything we discussed relating to the effect an engineer has on people, there seemed to be two extremes." Probably neither is right, nobody can tell you the right approach. The man who can intuitively tell which way to go will do the right job -- and will be recognized for it.
>
> "The basic benefit I derived was that as an individual in the Du Pont Company, I am not an 'Island Unto Myself', but a part of a living, thinking organization of people."
>
> "I was confused about how much authority an area engineer has -- and also his responsibilities. I feel now that he can have as much of both as he is willing to assume. It depends entirely on his initiative and ambition."

With minimum instruction the twelve to fourteen engineers have been involved in "work-related" team assignments; direct contact with division staff members; and interplay between themselves and those things which confront them in the performance of their work. They have each searched, analyzed and concluded for "themselves" certain things related to their authority, responsibility, and function as an engineer. They have experienced varying degrees of increased awareness and recognition for their relationship and impact on others.

EXHIBIT "C"

PAPER NUMBER 63-WA-308

AN ASME PUBLICATION

$1 PER COPY

50c TO ASME MEMBERS

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
345 East 47th Street, New York, N. Y. 10017

# Education for Technical Management

**E. H. FREIBURGHOUSE**

General Electric Company,
Schenectody, N. Y.
Mem. ASME.

The technical manager's main job is to see that designs are produced. His most important personal attribute is technical competence. Young engineers with management potential should have an accelerated experience in producing designs. Older engineers with some years of design experience have a greater need for enlarging or renewing their scientific and technological awareness. Examples of educational programs which are addressed to these needs within the General Electric Company are included. The first is the new engineering doctorate program developed in cooperation with Polytechnic Institute of Brooklyn. The second is the Modern Engineering Course which was originally conducted by UCLA.

Contributed by the Management Division for presentation at the Winter Annual Meeting, Philadelphia, Pa., November 17-22, 1963, of The American Society of Mechanical Engineers. Manuscript received at ASME Headquarters, October 4, 1963.

Written discussion on this paper will be accepted up to December 23, 1963.

Copies will be available until September 1, 1964.

# Education for Technical Management

E. H. FREIBURGHOUSE

## WORK OF THE TECHNICAL MANAGER

Technical management (as the words are used in this paper) has the responsibility for producing designs of products or systems which will be manufactured. Individual engineers produce the designs under the direction of the technical manager although there often are intermediate levels of supervision. The educational principles and illustrations which will be discussed are based on the assumption that the students are engineers, who have or may eventually have technical management responsibility, but who do not hold the broader responsibility for general business management. In other words, the engineering function is regarded as a piece of the manufacturing firm, having unique managerial requirements of its own.

The main job of the technical manager is to see that designs are produced. The designs, when translated into hardware, must have a value greater than the cost of producing them. This says that the manufacturer must be able to sell his output at a profit. It further implies that the designs

- embody advanced technologies;
- minimize the cost of materials and labor;
- satisfy a current or potential demand;
- meet quality standards which are representative of the company's other products and those of its competitors;
- enable the manufacturer to minimize his investment in new plant, equipment and competence.

Within General Electric we portray this work of the technical manager and his organization as the design process, Fig. 1. We believe this process to be the heart of the technical managing job. It must be understood by the manager, he must be personall equipped to deal with it, and causing this process to have a useful output (design) is his mission. Consequently, we must have an understanding of the design process if we are to have a basis for assigning priorities to various eduoational alternatives.

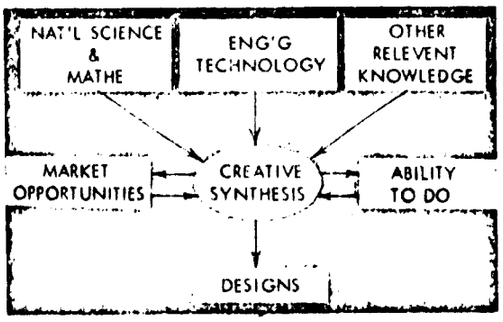



Fig.1 Design process

## WHAT SHOULD BE TAUGHT AND WHEN

Preparing men for technical management would be impossible if all aspects of the work had to be anticipated and thoroughly treated by formal educational courses. Based on our understanding of the design process we believe strongly that successful technical management has, as its foremost requirement, high technical competence. And because the time available for education is alwaya limited, the greatest emphasis must be placed on improving technical competence.

A second criteria is that of teachability. It is not enough to teach managers that they should plan, organize, integrate and measure unless you can also teach them how. Without the "how," the infinite words merely expand on the general truism "be good." Whereas philosophic discussions of managing have their place, this place is not in a crowded educational program for which there are already too many tangible subjects clamoring for attention. Many of the personal attributes which are intended as the result of these philosophic discussions can only be acquired through experience. In fact, it appears that a man's experience and associations are the dominant influences on his personal characteristics.

The age of the student affects the content and methods used in the educational program. For example, the recent graduate of a typical four-year engineering college who enters development or design engineering and who has the potential for a managerial appointment needs advanced courses in science, engineering technology, and mathematics. Perhaps his greatest need, however, is for an accelerated and guided application of the material learned in these and prior courses. As rapidly as possible, he must accumulate experience in producing designs. Both theory and design are necessary parts of the formal engineering eduoation and both deserve to receive credits. Unfortunately specialization with respect to product, task and timing has removed many of the "greater engineering" aspects from positions in which re-

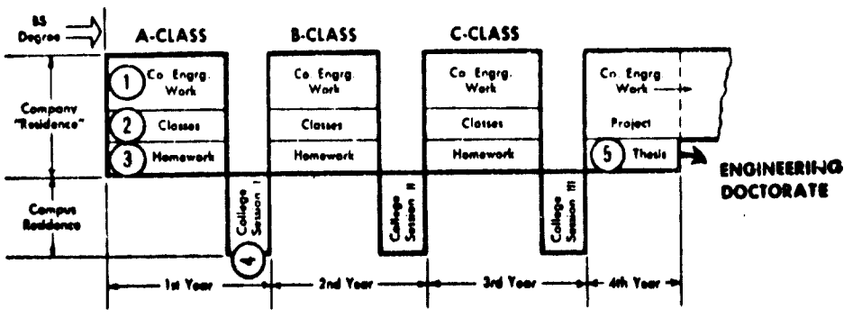



Fig. 2 Diagram of typical program - advanced course in engineering

cent graduates find themselves. This is not too damaging for men who spend most of their careers as technical specialists, but the potential manager needs a broader experience. On the other hand, it is essential that the education enable the man to work successfully as an individual engineer during the several years which necessarily must precede his advancement.

In contrast with the recent graduate, men who have already accumulated 10 to 15 years design experience need less practice in applying the theory. Their greater need is a broadening or renewing of their scientific and technological awareness. They face the prospect of managing younger engineers whose educations have included the new developments which are coming along at such a rapid pace. Such older students must be brought up to date on pertinent and recent developments in the fields of mathematics, science, materials, and technology which have a direct and dominating influence on modern engineering. Furthermore, it is undesirable and impractical to give such students a profound or even working familiarity with the subjects covered. They should receive an understanding of, and appreciation for, the more important scientific and advanced engineering concepts. The objective should be to highlight these new developments and to show their engineering applicability rather than to carry out long detailed derivations.

## EXAMPLES OF EDUCATION FOR THE "YOUNG" MAN

The Advanced Course in Engineering was established in 1923 to supply the General Electric Company with engineers having sufficient breadth and depth of technical understanding to make basic contributions in the development of new or improved products. Its objectives are to increase the abilities of the recent technical college graduate to:

1 Analyze and evaluate engineering problems as to both their significance and the appropriate economic and technical approach to their solution.

2 Apply effectively the fundamental and advanced principles of physics, mathematics, and engineering technology to the solution of actual engineering problems.

3 Present the solutions clearly and concisely so that results can be easily understood and utilized.

These objectives are aimed at developing competent engineers of professional stature, qualified for the total engineering job involved in producing successful products and systems through application of available technology, regardless of how advanced. Graduates of the course are expected eventually to provide technical management for the engineering work of the company.

Approach. The Advanced Course in Engineering is based on the premise that development of competent professional engineers requires a combination of formal study and practical experience. Engineering leadership requires not only the comprehension of advanced technical concepts, but experience in their practical application to engineering development and design problems. To provide this combination, the Advanced Course in Engineering consists of five major elements:

1 Design and development engineering work assignments as a member of General Electric's professional engineering staff.

2 Weekly or monthly class meetings for the presentation of theoretical subject material.

3 Homework problem assignments representative of actual engineering situations.

4 Periods of full-time campus residence for a concentrated program of formal graduate courses.

5 A development or design project, together with a thesis based on it, for those students who are candidates for the engineering doctorate.

These elements are fitted together to form a continuous three-year program of work and study, both on the job and on the campus, followed during

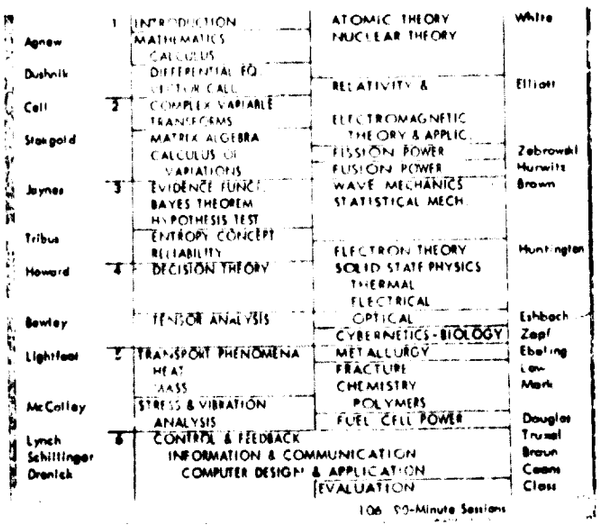



Fig. 3 Modern engineering

the fourth year by a work-related engineering project appropriate for the doctoral dissertation. They are indicated by the corresponding numbers on the diagram in Fig. 2.

Course Content. A-Class - The A-Class is designed to build competence in the application of scientific knowledge and analytical techniques. The emphasis is on learning to think from fundamentals in solving problems where handbook formulas are inapplicable.

Class work covers broad physical areas such as dynamics, elasticity, fluid flow, heat transfer, and electromagnetic fields. Basic mathematical tools such as differential equations, vector analysis and probability calculations are used as an aid to physical understanding. Homework emphasizes the importance of the structural elements of problem solution, such as understanding problem objectives, establishing proper assumptions, determining limiting conditions, hypothesizing the conclusions to be expected, and interpreting the actual, practical meaning of a theoretical answer.

Because of its emphasis on broad and basic fundamentals, the A-Class curriculum is the same for all members of the course. In the subsequent college sessions and B and C Classes, the student may select from among several courses that will permit him to specialize in broad fields such as electrical, mechanical or systems engineering.

College sessions. The college sessions present intensified graduate courses in advanced engineering theory and mathematics in such fields as linear and nonlinear systems, feedback control, communication theory, heat transfer, stress analysis, fluid mechanics, and modern physics. These provide the basic knowledge for handling complex problems in the fields involved. The subjects covered vary depending on which field of specialization is involved.

B and C Classes. These classes provide experience in engineering application of the topics previously learned, together with presentation of additional theoretical subjects as needed. C-Class assignments are the equivalent of design projects, based frequently on current unsolved engineering problems.

Engineering Project. The fourth year of the course is devoted to a design or development project which is part of the man's regular engineering work in his department, and the preparation of a thesis based on it. This should involve original contribution or investigation, the results of which are worthy of publication in a recognized scientific or engineering journal.

## EXAMPLE OF EDUCATION FOR THE EXPERIENCED MAN

In the Summer of 1961, two General Electric employees attended the first "Modern Engineering Course" conducted at Ojai, California by the University of California at Los Angeles (UCLA). Subsequently, in the Spring of 1962, UCLA agreed to conduct this course for General Electric engineering managers in our Crotonville facilities. Since receiving this initial help and inspiration, General Electric has gone on, with UCLA's approval, to conduct continuing sessions of the Modern Engineering Course.

The course content is itemized in Fig. 3, together with the number of 90-min lecture periods devoted to each topic. In general, the coverage falls into four major compartments, each of which is rather self-contained and independent, and yet which tie together sequentially into an integrated whole.

The key concepts that seem to be emerging from our experience with the Modern Engineering Course are as follows:

### Concentration on Technical Subjects

Obviously, the first and greatest problem in designing such a course as this is the difficult one of deciding what can be left out. There are so many "important" subjects, so many good ideas and so little time, that a severe and, admittedly somewhat arbitrary, selection process had to be exercised.

We believe strongly that successful technical management requires high technical competence in addition to the general management skills, and this course reflects this thinking. In this abbreviated six weeks course the "Time versus Topics

Dilemma" is so acute that we do not have time to review engineering and scientific advances and also to cover economic theories, sociology, psychology, and the developments on the political and international scenes. Therefore, by design, this course is restricted to mathematics, science and engineering fundamentals.

Unifying Concepts

Although the voluminous expansion of specialized technical knowledge is obvious to all, there is a less widely recognized, and possibly even more important, characteristic of this growing body of knowledge. This is the repeated discovery of new conceptual schemes that reveal the intimate relationships between phenomena and technical disciplines originally thought to be quite independent, or only distantly related. This growing "oneness" or unity of our technical knowledge is constantly being demonstrated by progressive advances in our engineering disciplines, in college engineering curricula and in scientific theories and mathematics. We have felt it both necessary and desirable to design this course so as to illustrate, and also to benefit from, these developments. In agreement with this viewpoint, this Modern Engineering Course has a major Physics-Solid State-Chemistry-Metallurgy sequence that not only describes some of the new engineering materials, but it demonstrates the basic unity of these "separate" disciplines.

Unification in Scientific Theories

Perhaps the most basic, most revolutionary and most important aspect of this unification trend is the continuous replacement of older "physical models" or theories of limited applicability with newer ones encompassing a much wider range of natural phenomena. The history of scientific development is marked by such milestones and indeed the foundations of traditional engineering can be expressed succinctly by Newton's laws of motion, Maxwell's equations, laws of thermodynamics, and so on.

Quantum Mechanics. One of the most important of these thought revolutions, is the magnificent superstructure that has been erected on the simple concepts and insight provided by Quantum Mechanics.

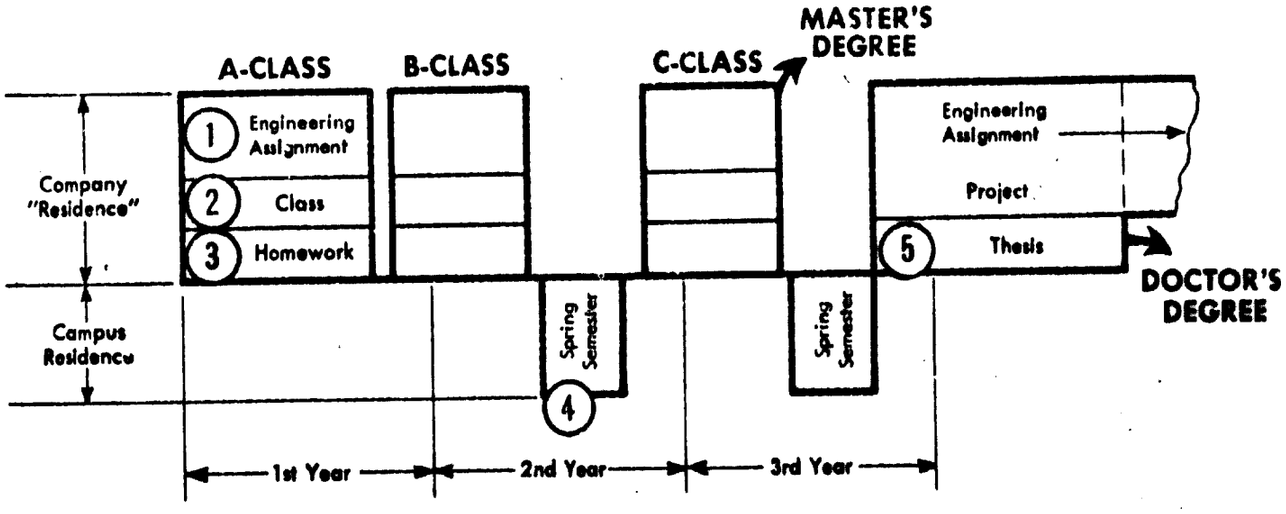
Relativity. In a completely analogous manner, a few basic concepts proposed by Einstein in 1905 have had such ultimate power in unifying many seemingly diverse facts and in predicting undreamed of practical and political consequences, we have included in this practical engineering course a session on the Special Theory of Relativity.

Statistical Mechanics. This is a third extremely important unifying scientific concept that has been stressed as one of the keystones of this course.

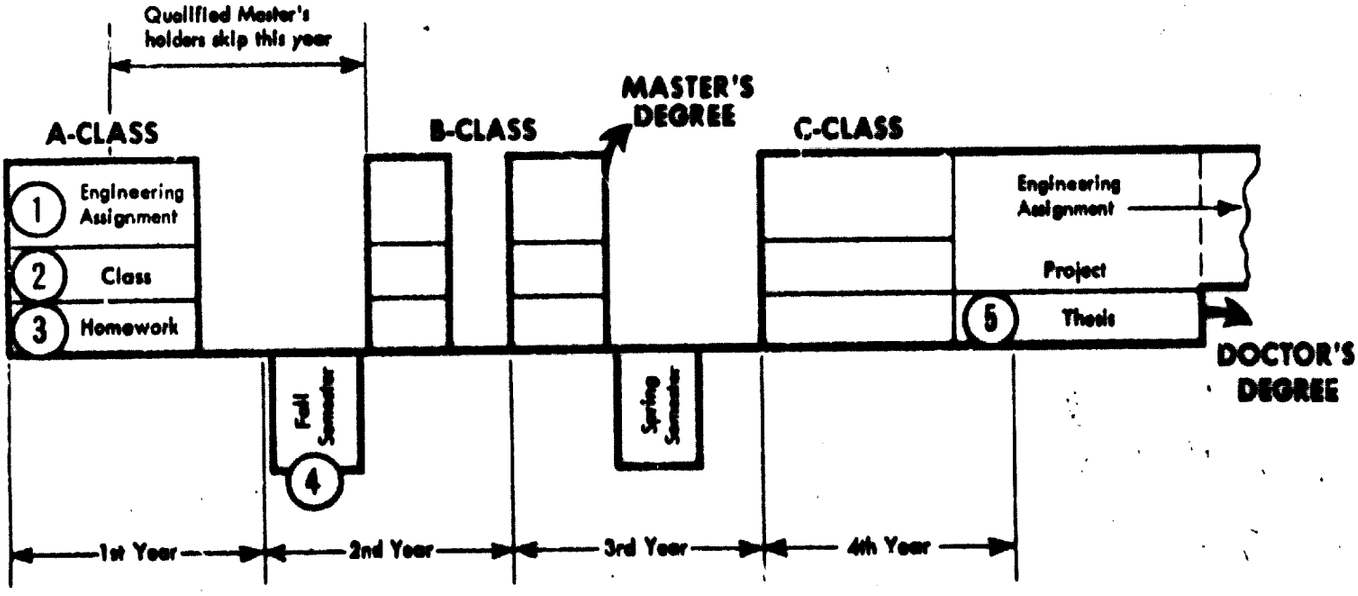
Mathematics. While the graduate of 20 years might reasonably suppose there would be little change in the proven mathematical principles of calculus, algebra, and so on we find, not only are many new fields being opened up very rapidly, but there are many new and more powerful ways of viewing - and teaching - the traditional mathematics. New similarities of approach and structure are seen and powerful, concise methods of representation shed new light on old ideas.

CONCLUSION

The era of single-handed engineering greatness achieved by tinkering in basement workshops seems to be passing. Perhaps its modern-day equivalent is the engineering team leader or manager. To use Mr. Ramo's colorful phrase, "Men are needed who can do the work of greater engineering," and many thoughtful people are convinced in light of the trends, that this need will be satisfied only if the engineering education process can be radically improved. It will be improved only as we recognize the true relative importance and teachability of alternative subjects.



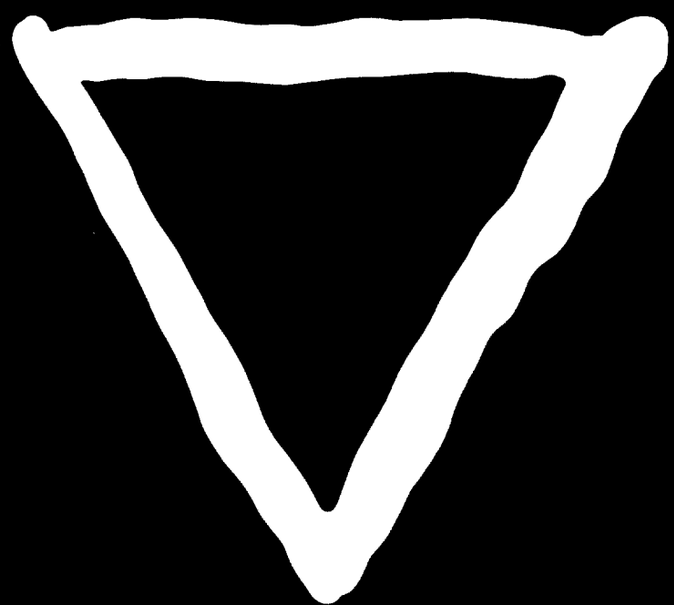

General Electric-Rensselaer Polytechnic Institute program.




General Electric-Polytechnic Institute of Brooklyn program.

3

# Engineering Careers in Westinghouse



19.8.74