# COOPERATIVE ENGINEERING EDUCATION: ITS APPLICABILITY TO THE PHILIPPINES

By

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*The Problem*

In interviewing plant managers at some 30 different industrial establishments in the Philippines, one complaint is repeatedly heard: "The newly-graduate engineers we hire are not immediately useful to us; they lack practical training." As a result, most industries plan a six-month to two-year training period during which time the fledgling engineer becomes acquainted with machines and processes he, in most cases, only heard about in school. Valuable time must be expended by experienced company staff in simple orientation and explanation. Graduates from only a relatively few engineering schools are actually sought after; the remainder are taken on any from necessity and must be carefully screened and examined for potential suitability to the company.

Most of the plans visited are striving to increase their productivity, since they face severe competition from their rivals in eastern Asia. What preventive measures can be taken, then, to avoid the loss of time, energy and money now being devoted to completing the education and training of engineers already granted degrees but still lacking in ability, through no fault of their own, to properly function as professionals?

*Possible Solutions*

One way to alleviate the situation is to have the schools greatly improve and expand their engineering laboratory facilities to provide more practical exposure of their students to machines and equipment. This is expensive, albeit helpful, because even the best school labs can hardly hope to duplicate the modern, complex equipment now prevalent in industry.

This then suggests that the industrial facilities themselves be utilized as far as practicable for engineering student training. A number of different approaches are possible and have been or are being tried in many countries. These approaches vary from full-time work at a factory or engineering office alternating with full-time study periods in school to co-sponsored projects of a practical nature and of varying duration.

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*Experience Elsewhere*

A look at what is done elsewhere can be of value. For instance, in Europe industrial practice requirements are commonplace for engineering students. Some pertinent examples and points of interest gleaned from UNESCO publications on the subject are as follows:

Finland — To graduate, the engineering student is required to have six to nine months practical experience in industry. (This requirement has been made optional for the time being, although extra credits are still earned in this way). Senior year projects are often carried out at industrial sites, or on subjects proposed by industry.

Switzerland, Belgium — Engineering students take practical training during vacation periods.

Denmark — Practical training sessions of six months to a year are required for students of the technical school and the engineering academy. Also industry representatives have a say in altering curricula and in examination procedures.

Austria — Industry examines changes in engineering curricula before they become effective.

United Kingdom — There is an Engineering Industrial Training Board which is responsible for placing of students for practical training.

USSR — Industrial training has an important role in the engineering curriculum, with about 15 percent of the total training time devoted to it. The training is undertaken during summer, usually after the third, fourth, and fifth years. As a rule, students perform jobs that are at the level of a certified technician. The last training session is done at the place of future employment assigned before graduation. The organization of practical training is the responsibility of industrial concerns.

The training periods usually have the following emphasis: First period, work on the factory floor, with machine tools; second, technology of production, familiarity with machines, instruments; third, operational, serve as assistants to head of a testing section; fourth, gather information for thesis project.

Engineering faculty members also are required to have a specified amount of industrial training, such as a three-month refresher at an industrial concern every five years to study the most recent advances in science and technology and prepare lecture notes based on these observations.

Poland — Industrial training is considered to be an essential part of engineering education in Poland and is treated as any other curriculum subject. Detailed programs of industrial work must be developed for each area of study and must be rigidly adhered to. A student is expected to complete four weeks of training in a factory during each summer vacation period and an additional four weeks during his final semester before being awarded a degree. During these periods the student is jointly supervised by the university staff and the factory personnel.

Other Countries:

Egypt — Second and third year engineering students are advised to spend their summer vacation as trainees in engineering offices or factories. This was once a rigorous requirement, but due to the increased number of students, this very important part of the engineering curricula had to be made optional.

Nigeria — Industry maintains that most of the newly-graduated engineers are inexperienced and not immediately suitable for employment; that further training is expensive and reduces the productivity of experienced staff who must be assigned to supervisory duties. It may, therefore, be necessary for the universities to become involved in some aspects of practical training. Cooperative programs with industry could provide the practical orientation needed to correct some aspects of the students' psychological attitudes towards work which constitutes a barrier to high productivity and efficiency.

In the United States, cooperative education or work-study programs are taking hold in a big way. However, this is not a new social invention. Way back in 1906, the University of Cincinnati engineering schools scheduled students for off-campus work as well as for classroom instruction. By the early 1960's, about 60 colleges in various parts of the country had adopted cooperative education and expanded its applications from engineering to almost every college course of study. Today there are over 1,000 universities, colleges, and community colleges offering cooperative programs, and the students enrolled in these program number over 200,000. This figure is expected to approach 1,000,000 in another decade. Cooperative education, as a means of bridging the gap between the world of learning and the real world of work, has really come of age in U.S.A.

An interesting example of what is happening in the United States is the case of Johns Hopkins University in Baltimore.

In 1913, the first engineering faculty joined the University, including appointments in civil, mechanical, and electrical engineering. From the beginning, the engineering curriculum at Johns Hopkins was dramatically different from others in the U.S. Students were to be exposed as much to a liberal education and scientific inquiry as to the technological methodology that was the central focus of other engineering schools.

An emphasis on breadth in engineering education continued at Hopkins in the 1920's and 1930's, when the rapid development of new technology depended so heavily on the understanding of basic scientific principles. After the war, however, while most engineering schools were trying to emulate the educational experience that Johns Hopkins had been providing for so many years, the University moved even further toward basic science in its engineering programs.

In 1966, the School of Engineering and the Faculty of Philosophy merged to form the Faculty of Arts and Sciences. Although engineering education continued at the University, this action greatly reduced its visibility. But the 1970's serious concern arose regarding the vitality and status of the engineering program. As a result, the engineering school at Johns Hopkins was restored. While the education of engineers remains firmly grounded in science and mathematics the new School of Engineering draws on a close pattern of interaction with industry in its curriculum and teaching methods. With the inception of Student Engineering Experience Program, developed with the cooperation of local firms in the Baltimore area, the previously very academically-oriented engineering school now provides engineering students with actual industrial experience during the schoolyear. This is, indeed, quite a reversal in approach and a sign of the times.

In the State of Florida, the expansion of cooperative education has been especially striking. Today, all of Florida's state universities have a cooperative plan in one or more disciplines, and four have it in all disciplines. While it is compulsory in some institutions, most Florida schools have chosen to make cooperative education elective. Upon graduation, the average cooperative student in Florida has about one year of professional experience and surveys show that a cooperative student receives salary offers three to seven percent above those of non-cooperative students. (There are now 12 schools in the State offering cooperative programs in engineering).

Some large industrial organizations, dissatisfied with conventional engineering schools which often fail to keep their instruction abreast of technological advances, and wishing to train potential employees more specifically along their own lines of endeavor, tend to operate their own training and management development centers. The most auspicious undertaking of this kind is the General Motors Institute (GMI) in Flint Michigan. GMI is a full accredited engineering and business college. Over 2,000 students alternate over a five-year period between classes on campus and work at one of the Corporation's plants. The curriculum includes social sciences, the humanities, and oral and written communications skills. A 12-week alternating work-study schedule, less disruptive to the learning process than the former 6-week schedule has been adopted now. Emphasis for engineering students is on economics and on practical laboratory/shop experience. (Ninety-six per cent of the graduates continue to work for GMI).

Another firm, the Lockheed-Georgia Company, has had a cooperative program in operation for the past 20 years, with over 400 students being accommodated. Their primary objective has been to ensure a continuous supply of professional personnel in a timely manner. A major study, conducted to evaluate the program, showed that:

(1) From 1952 to 1973, there were 428 trainees from 16 different colleges, with 271 or 64 percent of the students completing the program. Of those that finished, 95 or 35 percent returned to the company for permanent employed.

(2) Cooperative trainees who returned to the company permanently received promotions and pay increases at a faster rate than non-cooperative graduates.

(3) The average cost to the company to train each cooperative student who returned there to work was about $23,000.

According to the Lockheed study, benefits derived from the cooperative education program were:

(1) The company gained in that the program proved to be an excellent source of permanent professional manpower. The employees were well-trained and already had exposure to company policies and procedures. They adopted to their new jobs faster and progressed faster.

(2) The program was a source of temporary manpower to handle short-range, semi-professional peak loads and special projects, eliminating the need to hire permanent employees for this purpose or transfer employees from other departments.

(3) Cooperative trainees freed up higher paid personnel for more demanding and responsible tasks in the organization.

(4) The infusion of bright, young people brought new ideas and viewpoints into the economy.

(5) The program provided a screening process for prospective employees of the company, allowing evaluation of performance before firm commitments were made.

(6) A mutual industry-university relationship was fostered.

(7) Many intelligent and promising students, who otherwise couldn't afford to go to college, received their degrees through the cooperative program.

*Specific Types of Programs*

Two specific project-based cooperative programs are worthy of attention: (1) The University of Evansville (Indiana) one-year industry-sponsored senior engineering design project for all engineering majors (including cooperative students), and (2) the full four-year Worcester Polytechnic Institute (WPI Plan) approach. The former exemplifies a fairly straightforward, modest attempt to make engineering instruction more realistic, the latter, a much more radical departure from the traditional engineering school approach. Both are based primarily not on alternating full-time work, full-time study arrangements, but on joint industry-school-student efforts to tackle actual problems facing industry and society as a whole, in the case of WPI and work out their solutions to the maximum extent possible under limitations of time, money, and student experience. Details of both programs are given in the Addenda of this paper.

*Experience in the Philippines*

That school-industry relationships can prosper in the Philippines has already been proven by the Don Bosco Technical College in Mandaluyong, Metro Manila. Based on a highly successful technician training program involving placement of trainees in some 50 different industrial plants, all Mechanical and Electronics Engineering students at Don Bosco now undergo on-the-job training in many of the plants prior to graduation. The students work full time in industry during summer breaks after both the first and second years of study, after already having had exposure to shop practice in Don Bosco's own extensive shops and laboratories.

General objectives of the in-plant training program are to:

(1) Give the trainees a feel of working in an industrial atmosphere and experience in applying skills and knowledge he has been acquiring in school.

(2) Expose and orient the trainees to current trends, developments, and needs of a particular industry.

(3) Broaden the trainee's outlook on industrialization so that he may have the proper perspective and attitude during his subsequent schooling.

Some specific objectives of a particular program might be for the student to:

(1) Learn to read and interpret working drawings.

(2) Gain knowledge and appreciation of the different materials and operations involved in producing a finished product.

(3) Attain proficiency in the use of certain tools, instruments, and machines in setting up of a job or process.

(4) Learn something of quality control, safety programs, maintenance procedures.

A listing of some firms cooperating with Don Bosco and also with the Manila Technician Institute is given in the Addenda. However, two organizations which have taken leadership roles in providing on-the-job training opportunities for Filipino engineering students are the San Miguel Corporation and the Manila Electric Company (Meralco).

San Miguel takes third and fourth-year engineering students into their program, drawn as far as possible from the top ten per cent of their classes. In 1978, there were 118 trainees of all types selected from some 500 to 800 applicants. Of this number 60 percent were engineers. Trainees get two months experience during the summer recess which may be extended, if desired. All are eligible for complete medical care during the employment period, and receive more than the minimum wage. The Corporation takes the initiative announcing training programs, writing to schools to get lists of students, working with deans and department heads, interviewing and testing applicants, etc. All major engineering disciplines are covered. San Miguel has worked most closely so far with the University of the Philippines, De La Salle University, Mapua, University of Santo Tomas, and Ateneo de Manila, but will initiate a training effort in the Visayan area by 1981.

The Corporation wants the training to be meaningful to the student as well as to serve as a recruiting tool for the organization, and figures the out-of-pocket cost at only ₱2000 pesos per trainee. Department managers at San Miguel plants are asked annually to draw up lists of projected man-power needs and of special projects that students might be assigned to work on, and to actually interview prospective trainees themselves. When on the job, trainees are closely monitored. There is feed-back to the schools. The managers' efforts are also appraised by the trainees.

According to San Miguel's Training and Development Superintendent, schools here should take more initiative to develop cooperative programs, and he would be glad to meet with engineering school personnel to discuss curriculum development and long-range training plans of the corporation.

Meralco also has conducted a training program for engineering students (from one summer to one semester in duration), as well as for newly-hired graduates (a one-year program) for some years now. Electrical Engineering (Power) students are given maintenance practice at some 60 sub-stations while Electronics and Communications Engineers are assigned to various sites. Mechanical Engineers are sent to National Power Corporation generating plants, formerly operated by Meralco. At present, 16 to 24 engineering students can be accommodated yearly during summer vacation periods. This number could be greatly increased if training periods, requiring staggered academic programs, could be scheduled throughout the year.

In the Chemical Engineering field, some limited efforts have similarly been made to provide plant experience to students. At University of Negros Occidental-Recoletos, a six-week apprenticeship at the La Carlota Sugar Central is requirement for graduation. West Negros College places students in sugar mill positions to learn first-hand about production problems. Bulacan College of Arts and Trades has had students undergo short-term training experiences at the International Chemical Industries plant in Guiguinto. Chemical Engineering students from various schools have also been accepted from time to time by such organizations as Del Monte, San Miguel, Marinduque mining, and Universal Textile Mills.

The Mining and Metallurgical Engineering curriculum has a special significance in the Philippines since all students have long been required to undergo and eight-week summer practice session at a mining operation or in a metallurgical plant in order to graduate. This is easily possible because the enrollment is limited in this field. Since the summer practice requirement is usually met at the end of the fourth year, this involves the placement of around 375 students, a manageable number considering the magnitude of mining operations in the Philippines.

For graduation from the Industrial Engineering course at the University of Santo Tomas, three months of on-the-job training experience are required. To meet this requirement, the school arranges for three to six students to be placed per company following their fourth year of study.

In Civil Engineering, no formal arrangement has come to light for on-the-job training. However, many prospective Civil Engineers are employed as draftsmen, engineering assistants, construction assistants, etc., in the daytime while attending classes in the evening to get first-hand experience in their field.

In order to produce engineers who could be immediately of value to industry upon graduation, the Metals Industry Research and Development Center (MIRDC) is presently developing a curriculum, in conjunction with Pamantasan Ng Lunsod Ng Maynila, based on a German model with its pragmatic approach to educate practice-oriented engineers. This would lead to a Bachelor of Science in Manufacturing Engineering and would require six years of academic and practicum courses, or five years if all five summers were used for practicum training. Other even more specialized courses have been suggested, such as a degree in Packaging Engineering.

On the graduate level, the Construction Industry Board (CIB), in conjunction with Polytechnic University of the Philippines (PUP.), has recently established a School of Construction Technology to provide trained men to occupy key positions in the industry, such as project managers and engineers. A Master's Degree in Construction Management is granted upon completion of 34 course units, two papers equivalent to eight course units, and successful passing of a comprehensive examination. All courses are specifically and exclusively related to construction.

*Future Applicability*

If further and more widespread use is to be made in the Philippines of cooperative education methods, a great deal more flexibility in engineering curricula is required. About 48 credit hours are now mandatory in language and high school level social studies that could well be reduced. Other broadening but not essential technical subjects are dictated by the need to cover areas that are stipulated by the Professional Regulation Commission for professional licensing exams. Little, if any, time is left for elective sequences, specialization, industrial project work, and the like. Fortunately, machinery is being set by the MEC, through the EDPITAF Engineering Education Project and the NEC, to revise engineering curricula. It is to be hoped that those schools desirous of instituting work-study cooperative project approaches will be enabled and encouraged to do so.

As far as the schools themselves are concerned, glaring weaknesses have been noted in all but a half a dozen or so of the many engineering schools visited. These are primarily in the realm of engineering laboratory facilities and practical instruction. Almost all schools are geared toward producing academically and design-oriented engineers, needed in far fewer numbers, than the practically-trained and production-oriented engineers industry wants so badly. Some schools have far too few engineering students and are too limited in scope, offering only one or, at most two major engineering disciplines to justify sizable expenditures necessary to properly equip laboratories and shops. Cooperative programs may be their only salvation, and practice-oriented instruction their only meaningful contribution to engineering education. Other schools have far too many students for their limited facilities, yet would face a formidable administrative load if they were to try to place all or most of their engineering students in on-the-job training situations. However, since many engineering students, as well as engineering faculty, now seek and find employment on their own, some less random and more directed efforts along this line could eventually lead to closer and mutually beneficial school-industry relationships.

The absorptive capacity of industry for accommodating engineering students, however, needs study. Since so few schools have so far attempted any formal or even informal relationships, it is hard to say how many students could actually be placed, what Governmental actions may be needed (such as tax incentives), what the situation might be in the provinces vis-a-vis Metro Manila, etc. However, the growth of cooperative education in the U.S. in recent years is reason enough for optimism since many of the same firms are represented here. For instance, in the States, such corporations as General Electric, Burroughs, Xerox, IBM, Caterpillar Tractor, and Ford employ better than 200 to 500 cooperative students each. General Motors takes 3,000 a year, and for that matter, U.S. Government agencies utilize 8,000. Most employers, though, are small and medium-sized companies, numbering some 30,000, which accept from one to three students each and find it beneficial to their business. Expansion of cooperative efforts here certainly warrants looking into as one way of improving the practical aspect of engineering education.

## ADDENDA

### I. UNIVERSITY OF EVANSVILLE: A Modest Approach

The primary goal of the University of Evansville School of Engineering is to prepare graduates to enter the world of industry. The fundamental objective is to provide each student with an opportunity to work on the solution of a realistic engineering problem. This is aimed at enhancing the young engineer's ability to organize, plan, and carry out the solution to practical problems, communicate the solution to others, and practice the high standard of personal integrity expected of an engineering professional.

The University is in favor of a "mix" of the regular engineering curriculum and projected-based education, a rather modest approach. The principal innovation is the adoption of a year long-industry-sponsored senior engineering design project. All engineering majors, including the cooperative students, are required to take the course to graduate. Student teams can be made up of one to four students, with a faculty adviser serving as consultant, and a designated engineer from the sponsoring industry. A formal legal document is drawn up to protect all parties concerned.

The course is designed in four quarter year sequences:

1. Design Seminar — Explore topics of current interest available for design projects; tentative selection of topic and industrial co-sponsor; formation of student team.
2. Design Project, Phase I — Project planning; identification of requirements; development of specifications; preparation of written proposal.
3. Design Project, Phase II — Preliminary studies; analysis; design effort; preparation of status report.
4. Design Project, Phase III — Final design; experimental development and testing; formal written report; oral review in which results are summarized, demonstrated, and defended.

During the proposal stage, the student must define the problem by reviewing the existing technical literature on the subject and by interfacing with the industrial co-sponsor to determine the particular constraints. Throughout the project, he must recognize and confront such important facts of engineering as cost analysis, availability of materials, equipment selection, and time schedules. He is also required to reach technical decisions on the basis of compromise and common sense, since money, equipment, or information is seldom sufficient to obtain the ideal solution. The student is given maximum opportunity to effectively manage the project.

Regarding cooperative plan students, although the cooperative plan student has had considerable exposure to industry, few of them have the opportunity to plan and carry out an in-depth project. The student, however, could capitalize on his experience by arranging to carry out such a design project with his employer as co-sponsor, and advantageously, because of his familiarity with the company, its facilities, and where and how to get things done. Some of the work might even be accomplished during a regular work period, thus accelerating his academic schedule.

## II. WPI PLAN: A Radical Approach

### *General Aspects*

Worcester Polytechnic Institute (WPI) in Massachusetts restructured its undergraduate program in 1970. The purpose of the Plan is to educate scientists and technologists who are not only competent in their specific fields of expertise, but are also humanely aware of the need of the society. Self-initiated learning (Autonomous Learning) is a central theme of the Plan.

The restructuring of the educational process took place after a thorough planning over two years. The new degree requirements of the WPI Plan are meant to ensure that graduates will develop the following attributes:

— Competency in student's major field.

— An ability to learn independently.

— An ability to integrate knowledge and solve problems.

— A breadth of knowledge in arts and humanities.

— A sensitivity to the societal-humanistic-technological interactions.

The academic courses *per se* do not establish degree qualifications. They only prepare the students to accomplish the following *four degree requirements,* which are derived from the goal of the WPI Plan:

1. MAJOR QUALIFYING PROJECT (MQP): MQP represents a project activity *in the major area* of the student performed at an advanced (bachelor degree) level. This project will be equivalent to three courses and is normally spread over three terms. The project will serve to integrate the knowledge that the student has learned and intends to be a vehicle for self-initiated learning. It is adviced by a faculty member who will evaluate the project at its conclusion. Although there is no such rule, most of MQP's are done in the senior year.

2. INTERACTIVE QUALIFYING PROJECT (IQP): IQP is a project activity involving the interaction between technology and society. This project is of the same duration and format as MOP, and of equal importance.

3. SUFFICIENCY: Sufficiency in a minor field of study is intended to broaden the overall educational program of the student. This will be in the arts and humanities for engineering majors. Each student must complete five thematically related humanities courses followed by a project or independent research study dealing with the same theme.
4. COMPETENCY EXAMINATION: Each student is required to pass a competency examination in the major field of study. This is not a three-hour test of the facts memorized over four years but rather a test of the ability to solve a problem in the major field given over three to five days, including both written and oral parts.

IQP's are done on a college wide basis. In view of the strong societal orientation in the civil engineering field, the faculty of the Department are actively involved as IQP advisers and chairmen of the established IQP groups. In an IQP, it is quite common to find students from different departments working together in the same group. Most faculty advisers regard this as highly desirable, since the student is exposed to viewpoints which may be quite different from his or her disciplinary bias.

The advisory role of the faculty member is vital to the success of the educational program of WPI. Each undergraduate is assigned an academic adviser who helps the student reach his educational goal. This responsibility is made a part of the faculty member's academic load. In addition to the academic advisers, each student has a humanities adviser and two project advisers. Since each student's program is individually constructed to meet his educational goals, the adviser's role is extremely important in making sure that the student's program is professionally sound and meets all the requirements of the Plan.

The results of a student and alumni evaluation of the WPI Plan from 1972 to 1978 revealed that the WPI Plan is achieving its educational goals in a positive manner. The study found that, the WPI graduates were generally doing slightly better in comparison to the traditional engineering college graduates in terms of their performance and were more effective communicators. They were working in larger companies, sometimes in jobs not traditional for their major field. They tended to get more involved in additional education. Their supervisors consistently rated their engineering skills as being good.

With regard to projects, the criteria are: (1) the project must meet the educational objectives of the college, and (2) the project topic must fall within the area of interest of individual faculty members. Topics should present sufficient complexity to require the effort of a project group of two to five students.

Project topics are usually problems of sufficient importance to the organization that a high degree of interest exists in the student's progress, but not of such immediate concern that the organization is solely dependent on the student's efforts for a solution to a critical problem.

At the beginning of the Plan, there was concern about the availability of meaningful projects in large enough numbers. That concern is no longer valid since over 200 off-campus sponsors, both from governmental and private sectors, have enthusiastically supported the project activity with good project topics, liaison advisers, specialized laboratory equipment and in many cases financial support. At present, there is a waiting list of off-campus organizations willing to sponsor projects.

## III. LIST OF COOPERATING INDUSTRIES IN THE PHILIPPINES

The following industrial organizations have an established working relationship with Don Bosco Technical College in Mandaluyong, Metro Manila, regarding the on-the-job training of Don Bosco's student (both technicians and engineers):

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| NCR | PAL |
| Phil. Refining Corp. | Arsenal, MND |
| MMTC | EEI |
| Meralco | Permaline Ind. |
| United Audio | Union Carbide |
| IBM Philippines | Benguet Cons. |
| ITT | Delta Motor Corporation |
| Cebu Shipyard | GM Philippines |
| Philec | United Laboratories |
| AG & P Honiron | Shell |
| Itemcop | Elitool |
| Creative Trade Center | Vetronics |
| Pemco | Philacor |
| Singer Industries | Marsteel |
| Phelps Dodge | San Miguel Corp. |
| Dynetics, Inc. | BRC, PNOC |

Other organizations are held in "reserve" or are used on a sporadic basis by Don Bosco in the event of additional or unusual training needs.

Some of the same firms work in cooperation with the Manila Technician Institution (MTI) to provide technician trainees with practical experience in a work situation. Additional industrial establishments cooperating with MTI are:

- Electro-Tech. Corporation
- Electronics Specialists, Inc.
- Canlubang Sugar Estate
- Food Terminal, Inc.
- General Electric (Phils.), Inc.
- CDCP
- Forest Products Res. & Ind. Rev. Commission
- Philips Elect. Lamp
- Romago Elect. Co., Inc.
- Machine Tools Mfg.
- Tennessee Chemical Corp.
- Radio Communic. of the Phil. Islands
- People's Car Inc.
- Manufacturers' Eqpt: & Supply
- S. C. Johnson
- American Wire and Cable
- California Manufacturing
- Caltex (Phils.)
- NPC
- LMG Chemicals