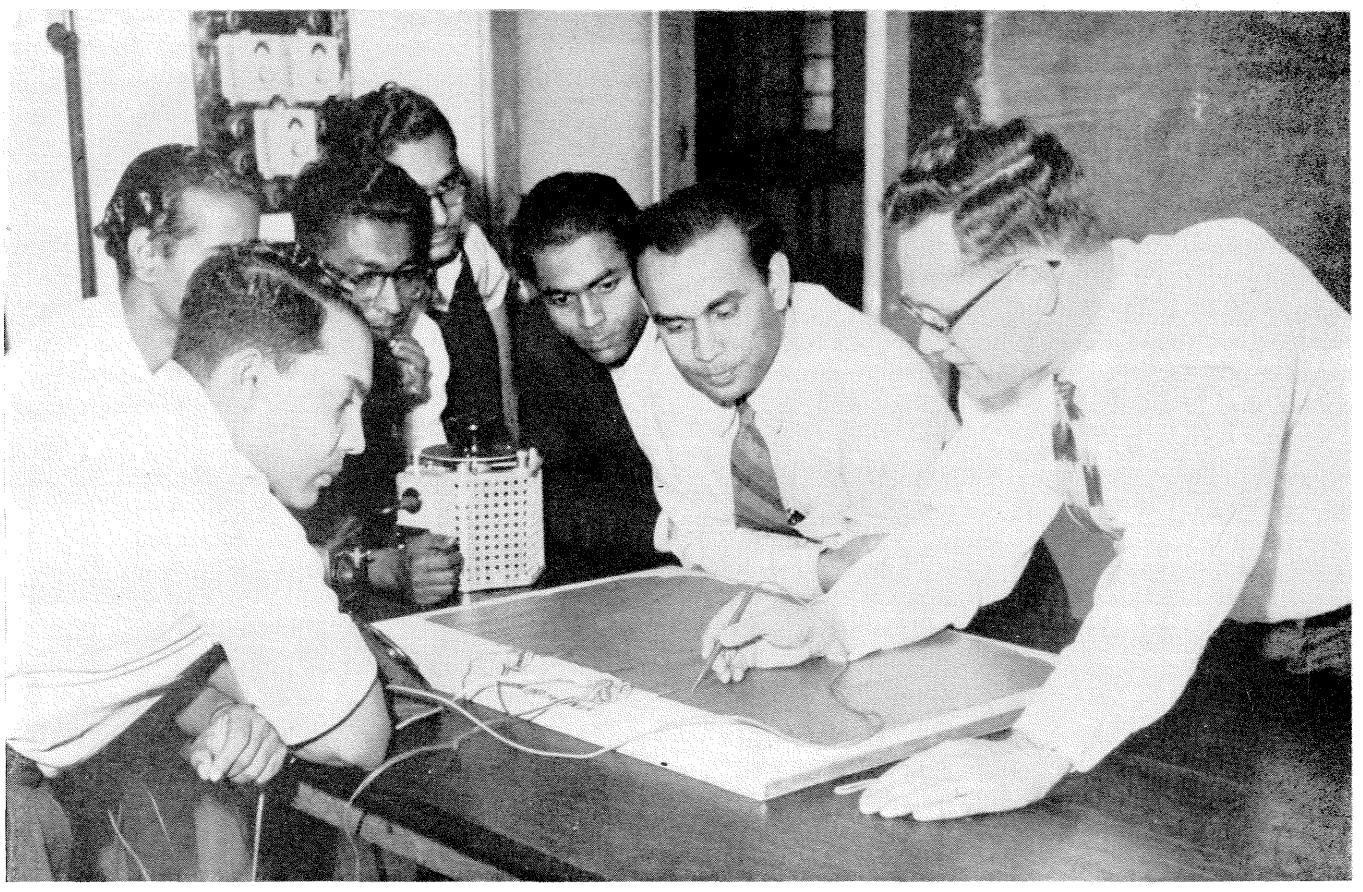

As guest professor at Bengal Engineering College, Dr. Ingersoll demonstrates an analog field plotter.

ENGINEERING EDUCATION IN INDIA

INDIA STANDS TODAY as the unparalleled challenge of the free world—one-seventh of the earth's population on a land area of less than half that of the United States, having an average living standard which is about the lowest in the world. Whether India's democracy stands or falls in the face of Communist pressure in Asia will depend on whether it can deliver the goods; that is, whether it can produce a rise in the standard of living comparable to or better than that reportedly taking place in countries such as Communist China. To utilize the relative abundance of natural resources and unskilled labor to raise the standard of living of the masses, to feed, house and clothe India's 380 millions is largely an engineering task. It must be accomplished almost exclusively with the products of the engineering education system in India, and thus this system merits careful scrutiny by all of us who are counting so heavily on India to make a success of her democracy.

Engineering schools in India date back almost as far as our own, with the establishment of Thomason College of Engineering (now the University of Roorkee) in 1847, and Bengal Engineering College in 1856. The graduates from these and later engineering schools of British India, however, were utilized mainly in the government supervisory posts for doing routine work of operation and maintenance.

Thus, engineering education in the past did not suitably equip the trained men to initiate new designs or projects. The real engineering work was consistently done in the home country, England. The fruits of this system, eight years after independence, are still much in evidence in India today. American guest professors in India generally agree that the qualities which Indian students lack most are initiative and imagination. It is a part of their unfortunate heritage of two centuries of subjugation.

Immediately upon independence the Government of

To feed, clothe and house India's 380 millions is largely an engineering task. Here is how India is meeting her need for engineers.

by ALFRED C. INGERSOLL

India took bold steps to improve facilities and instruction for the training of research scientists, high-grade engineers and technologists. The Central Government appropriated some $4,000,000 for new building and research equipment in 40 existing institutions, and provided another $500,000 annually for aid in employing qualified staff.

There are today some 49 engineering colleges and technological institutions in India offering courses in many branches of engineering and technology. About 30 of these offer the bachelor of science degree—on a par with our own—and, of these 30, about 14 are equipped to give graduate training and research, some leading to the master's degree and a very few to the PhD. The remaining institutions offer diploma courses, something like a junior engineering course, requiring only high-school preparatory standing.

The geographical distribution of these institutions is fairly representative of India's urban population distribution. Everything having to do with education, science, engineering or the like is conveniently divided into four regions in India—northern, southern, eastern and western—with the big cities of Delhi, Madras or Bangalore, Calcutta and Bombay, respectively, the focal points of these regions. Thus, the northern region has nine colleges of engineering and technology located in Delhi, Banaras, Kanpur, Aligarh and Roorkee. The eastern region has six institutions, three in Calcutta and two in Bihar, plus one more that will presently deserve special mention. The southern region has some 13 institutions, located in Bangalore, Madras, Hyderabad, Waltair, Trivandrum and Mysore. (One of the southern schools, in Bangalore, deserves special mention for the length of its name—Sri Krishnarajendra Silver Jubilee Technological Institute). The western region has four schools, located near Bombay and in Nagpur.

The total enrollment in 31 engineering colleges and engineering courses of arts and science colleges in 1951-52 was 12, 293 men and 11 women. The output in that year was 2,205 bachelor's degrees and 1 master's degree. In addition to this upper echelon we must add 27 colleges offering the diploma course, with an enrollment of 8,094 men and 3 women: the output being about 2,000 diplomas in that same year.

The total number of engineering students of India is on the order of 22,000. This works out to about one student of engineering for every 17,000 of population, just about one-tenth the corresponding ratio in the United States.

On the supply side, almost every college reports that there are from two to three times the number of qualified applicants as there are spaces available in the school. Those desiring to study engineering, but inadequately prepared, number still more. At Bengal Engineering College there are annually about 1200 applicants for admission. A competitive entrance examination is given at the college over a three-day period in the spring, and about 180 students are selected for admission.

As to demand, the employment picture is not as rosy as it is in the States, where each graduate can choose from among several opportunities, but unemployment of graduate engineers who have completed some practical training is negligible. This is in marked contrast to the overall picture of college graduates in India, among whom there is a great deal of unemployment (to some extent self-imposed, since most college graduates will accept only certain kinds of jobs—usually the ones we designate as white collar jobs). Referring to the class of 1955, the principal of one college reported that there were once again as many openings in civil engineering as the college could supply, half again as many in mechanical engineering, and not quite enough jobs immediately available in electrical engineering.

As India's industrialization proceeds through the various five-year plans in progress, the need for engineers will, of course, increase. The demand for engineers in private industry is largely a matter of educating the employer to the advantage of using engineers. This, however, depends in turn on one ingredient of the Indian mixed economy which is not present in any noticeable strength—competition. Until the Indian industrialist realizes that he can use engineering skills to turn out a product which is better or cheaper than that of his competitor, the employment of engineers in Indian industry will always lag behind that in the United States and similar competitive enterprise countries.

The development and improvement of technical education in India are guided by a body called the All-India Council for Technical Education. On this council are representatives of education, industry, legislators and specialists. The body has eight Boards of Study and four Regional Committees.

One of the most interesting developments, growing out of a recommendation of a committee of the Council, has been the establishment of the first Central Government higher technological institute, called the Indian Institute of Technology. This school is located in Kharagpur, near Calcutta, on the grounds of what was once an American air base (in fact it was the western terminus of the Ferry Command-run over the Himalayas, known as "the Hump").

I.I.T. is patterned after the Massachusetts Institute of Technology, which Indians consider the world leader in the business of engineering education. The first four-year class of students graduated this year. I.I.T. has an active graduate study and research program in eight fields, ranging from production technology and electrical communications to combustion engineering and applied geology. The estimated expenditure of establishing I.I.T. was $6,000,000. The institute will cater to 1,320 undergraduates and 400 post-graduate students and research workers.

Other central government institutes are proposed for Bombay, Madras, and Kanpur. This will round out the program of having a center for advanced engineering work in each of the four sectors.

Graduate students only

The Indian Institute of Science in Bangalore is a Central Government project (originally private) of a special sort. No undergraduate work is given at all, and only the upper crust of students with bachelor's degrees from other schools in India can come for graduate study and research. The Institute awards no advanced degrees, only associateships in science and diplomas in engineering. The student works under his major professor on a research project, but his thesis is frequently submitted to specialists abroad before it is approved, and the degree, if any, is granted by his mother institution. They are already recognizing a certain amount of difficulty with this complicated system, and at least some departments may eventually be set up on an advanced-degree basis.

On a pure research level, we should mention the Central Government Research Laboratories in physics, chemistry, metallurgy, fuels, glass and ceramics, drugs, foods, roads, buildings, electronics, electro-chemistry, salt and botany. These have all been initiated since independence, and will presumably direct the nation's efforts in her technological advancement through the various five-year plans. Furthermore, they will also absorb a good part of the graduate-student output while private industry is still learning the value of hiring engineers with graduate degrees.

In 1951-52, the year for which enrollment figures have previously been mentioned, the average annual cost per student in India's 31 engineering colleges was $194—67.4 percent of this coming from government funds (either state or federal), 22.9 percent from student fees, 1.6 percent from endowments and 8.1 percent from other sources. In the 27 engineering schools offering diploma courses the annual cost was only $103 per pupil, this derived about 75 percent from government funds and 25 percent from fees.

At Bengal Engineering College the fees for one academic year are as follows: tuition—$34 for students in the first two years, $42 for students in the final two or three years; dormitory—$10 for a double room, $20 for a single; meals — $70; incidentals — $10. These amounts would seem reasonable enough to us as *monthly* charges, but we must remember the enormous ratio of per capita incomes between India and the United States, which is 27 to 1. This means that a year in college would cost a senior student in India an apparent $3,900.

Faculty salaries

On the other side of this ratio matter, we can take a look at faculty salaries, which range from around 300 rupees per month for a demonstrator or instructor to Rs. 1,500 or better for a professor. Consider an assistant professor at Rs. 1,000 or $210 per month. To the American, his salary looks like $210 times 27 or $5,700 monthly—but remember that on this same scale a refrigerator would cost $8,500 or a small Hindustan automobile, $60,000! Either one is generally out of the question for a college professor.

At Bengal Engineering College, which is representative of the conventional type of engineering college in India, the curriculum is not greatly different from that in our own colleges insofar as courses and material covered is concerned. The student is supposed to be well grounded in physics, mathematics and chemistry from his intermediate science work before he ever comes to B.E. College. In contrast to a school like Caltech, however, the physics department is a relatively minor adjunct to the engineering groups, and there is no provision for a post above that of assistant professor. The work of the physics department is principally in the communications field.

In the senior year, about 35 percent of the student's time is devoted to his project work, which may be the design of a bridge or structure, including detailed drawings which are far more elaborate than the writer has seen at engineering colleges in the States. The reason for such specialization was once explained by the head of the civil engineering department this way: "Our problem is different from yours. In the U.S.A. an engineering graduate can go to work in an engineering office where he learns the business while he is working. In India, on account of the shortage of trained engineers, the fresh graduate may often be placed in a position of considerable responsibility, with nobody

to supervise his work. He has to produce reliable work right away."

There are between 80 and 100 civil engineering students in any normal class. They meet together for lecture classes in the theoretical subjects. For tutorial or computation sessions they divide into four groups. The student is expected to attend class 36 hours per week, there being 7 class periods per day on Monday, Tuesday, Thursday and Friday, and 4 each on Wednesday and Saturday. Generally a student sits in lecture classes nearly every day from 7 to 11 a.m. After an hour and a half break for lunch he is back for tutorial, laboratory or project work until 3:30 p.m. Athletics will consume another two hours or so and then, after tea, the student may be able to study for a couple of hours before dinner at about 8:30.

Formal Classes

We see, then, that the Indian engineering student spends about 50 percent more time in formal classes than does his American counterpart. Specific homework assignments, with certain problems to be worked out and handed in each period, are few and far between in the traditional British teaching system.

Students are rarely sent to the blackboards to work problems in class. By and large there are no textbooks as we know them. The library may have 10 copies or so of a book that is recommended by the professor, and these must be shared among 80 students. Most of the student's time in lecture classes is spent copying into his notebook material which the professor puts on the blackboard. From earliest school days, lots of emphasis has been placed on memory work, so the student is likely to do a pretty good job at reproducing what he has written in his notebook on an examination later (and all are closed-book exams, incidentally).

The Bengal Engineering College gives three required examinations per year in each subject. These are generally three hours in length, and are of about the same caliber as our quarterly exams. The questions are set by the instructor who teaches the course and the same person marks the papers. A student must have a satisfactory record—roughly 40 percent—on these examinations before he is permitted to take the University of Calcutta examinations, which come principally at the ends of the second and fourth years. A student's passing and official grades are determined almost entirely by the results of these examinations.

A sidelight of the examination system that is hardest for Americans to believe is the secrecy in which the results are held until the right time. At the end of his third year, for example, the student takes certain University exams which pertain to courses he has completed but he is not allowed to know the results of these exams until more than a year later, when the results of his fourth year exams are also made known!

These all-important University examinations are given in two parts. The internal part is usually made up and graded by the instructor who gave the course. The other part is set and graded by an external examiner, usually a professional man who has been in practice a number of years. The idea behind this is laudable, to keep the college from becoming inbred in its teaching, much in the manner that we employ for professional registration exams. In practice, however, it is frequently difficult to find a practicing engineer who has kept in sufficiently close touch with modern developments to make up a creditable set of questions. It is very common, therefore, to farm out the external examiner work to professors of other schools. The questions are set with no more knowledge of the courses involved than that given in the syllabus printed in the catalogue.

Following his four academic years at B.E. College, the student then puts in a year of practical training as a sort of apprentice engineer, either in government service or industry, during which time he is paid practically nothing. The bachelor's degree is granted by the University of Calcutta in January following the year of practical training (for which there is no exam). Thus, although the engineering course is considered a four-year affair, the student cannot obtain his degree in less time than five and one-half years after he enters the college as a freshman!

The Indian engineering student engages in a more extensive athletic program than does his average American counterpart. Group games such as soccer—which they call football—cricket, basketball, and field hockey, are played daily, according to the season of the year, and there is smart competition between the teams of Bengal Engineering College and those of other schools or organizations nearby. Indians are also strong on tennis, badminton, and track events, and once each year the alumni gather on the campus for a big track meet and other festivities such as intercollegiate debates and the like.

Social life

Social life as the American student of engineering knows it, however, is non-existent in India. Although there are plenty of colleges for women in the Calcutta area, the idea of a dance, or even a co-educational picnic, would be unthinkable. A student may occasionally bring his sister on the campus on a Sunday afternoon, but even such visits are rare. This taboo stems from the traditional concepts of marriage, either Hindu or Muslim, in which the bride and groom meet for the first time at the wedding, all the preliminaries having been arranged by the families beforehand.

The big events are the holidays, which come with alarming frequency for an American. There are some twenty-five holidays listed in the prospectus of B.E. College, and even these are only about half of the ones they used to have! On the principal holidays the students gather for some type of convocation or ceremony in the morning, usually followed up by a social func-

tion in the evening, including music and refreshments.

The gayest holiday of the year is Holi Day or the festival of the colors. The students start early in the morning squirting each other with dye of various colors. They then come systematically after all the professors who have not had the prudence to leave the campus for the day. The refreshments in the evening are financed from the ransoms offered by the bedraggled faculty members in exchange for reasonably gentle treatment.

The writer must remark on one of the most spirited meetings of the students which he attended. It had all the flavor of an athletic contest among American students, including cheering, stamping of feet, a professional referee, and even various expressions of disapproval. The contest was not athletic, however, but rather competition in the reading of Bengali poetry!

Engineering educators in India, when asked what they considered to be the major problem facing engineering education in India today, invariably reply, "Teachers!"

We saw earlier that the ratio of engineering students to total population in India is about one-tenth what it is in the U. S. When we now consider that the teacher-student ratio in India is perhaps one-fifth what it is in the States, we have the interesting summary that the ratio of engineering teachers to population in India is about one-fiftieth of what it is in the States. This means that if India is to think in terms of building her economy and living standard to the ultimate level of the western world, she should be thinking in terms of expanding her teaching and research staff in engineering about fifty times or 5,000 percent! This points up the critical shortage of engineering teachers. It is a staggering task, and one in which the technically advanced countries of the world can participate for the next several decades before the supply is in any way adequate.

Attracting teachers

The only way that the needed teachers can be attracted into the profession is to offer them salaries, security and working conditions on a par with those obtainable in Indian Civil Service or private industry. This requires new sources of money for engineering schools. In this it is to be hoped that India will follow the lead of Australia, where private industry has recognized its obligation to engineering education and is supporting research and teaching in significant amounts.

In some of the problems of engineering education, India is receiving significant help from the various international aid programs. The American Technical Cooperation Mission, for example, involves not only some 40 American specialists at various schools in India but, more important, a like number of Indian faculty members who are getting advanced training in the United States for a year or more.

Several engineering schools have visiting professors sponsored by UNESCO, these men being predominantly German and English. Still others are provided by ECAFE (U.N. Economic Commission for Asia and the Far East) and the Colombo Plan, in which Canada is so active a participant.

Of the Indian participants who have come to the U. S., some are taking advanced degrees in institutions here. Others are engaged in programs of visiting many colleges and participating in seminars and the like. All of them are getting good opportunity to travel around the country, observing engineering works. It was originally hoped that more of them could be stationed as observers in various industries, from which they have so much to learn, but the strict security regulations on almost all U. S. industries have prevented this program from materializing.

Facing the responsibility

At some engineering schools in India programs are underway which clearly show the extent to which India is facing her responsibility in being a leader of the other free nations of Asia and Africa. Take, for example, the University of Roorkee, where there was inaugurated just last month the first Asian-African Training Center in Water Resources Development. Engineers from countries all over Asia and Africa are meeting there for a year's time in which they pool their experience and technical knowledge in the management of water resources to advance their countries toward total self-sufficiency. In this program, too, guest specialists are being provided through the TCM program, the U.N. Technical Assistance Board, and ECAFE.

At Roorkee, too, another experiment is underway, called *Shramdan*, which involves the students and staff working together with their hands, using their engineering principles to build structures which will be of service to the campus and community. In this way, students and staff have constructed a swimming pool, an open-air theatre, and a substantial addition to the students club building. Similarly, students at I.I.T. are constructing their own swimming pool, while at B.E. College the more socially conscious students have built a small bridge over a canal in a village not far from the campus. They undertake a different community service engineering project of this sort every year.

Another worthwhile program at Roorkee which deserves mention is that of Refresher Courses for Serving Engineers. These courses, which run about three months each, are designed to bring engineers serving in various parts of the Government up to date on recent developments in engineering.

These examples serve to show that engineering education in India is dynamically developing its own characteristics of service to the community, the nation, and even to the family of nations in Asia and Africa. While it keeps these lofty goals amidst the tribulations of severe shortages in funds and manpower, we of engineering education in the western world can be proud of our participation in it.