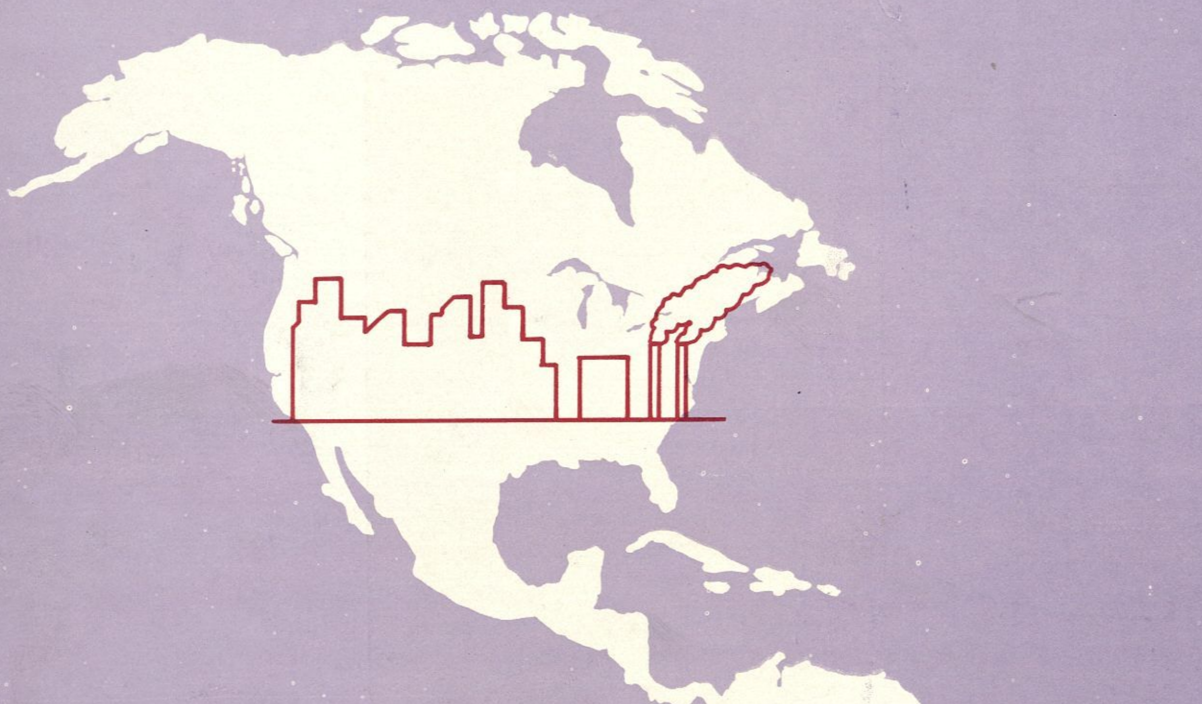
The COLORADO Engineer



MARCH, 1967

UNIVERSITY OF COLORADO

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The
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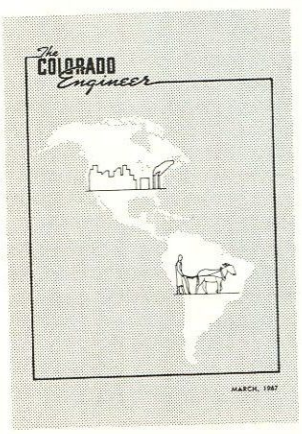
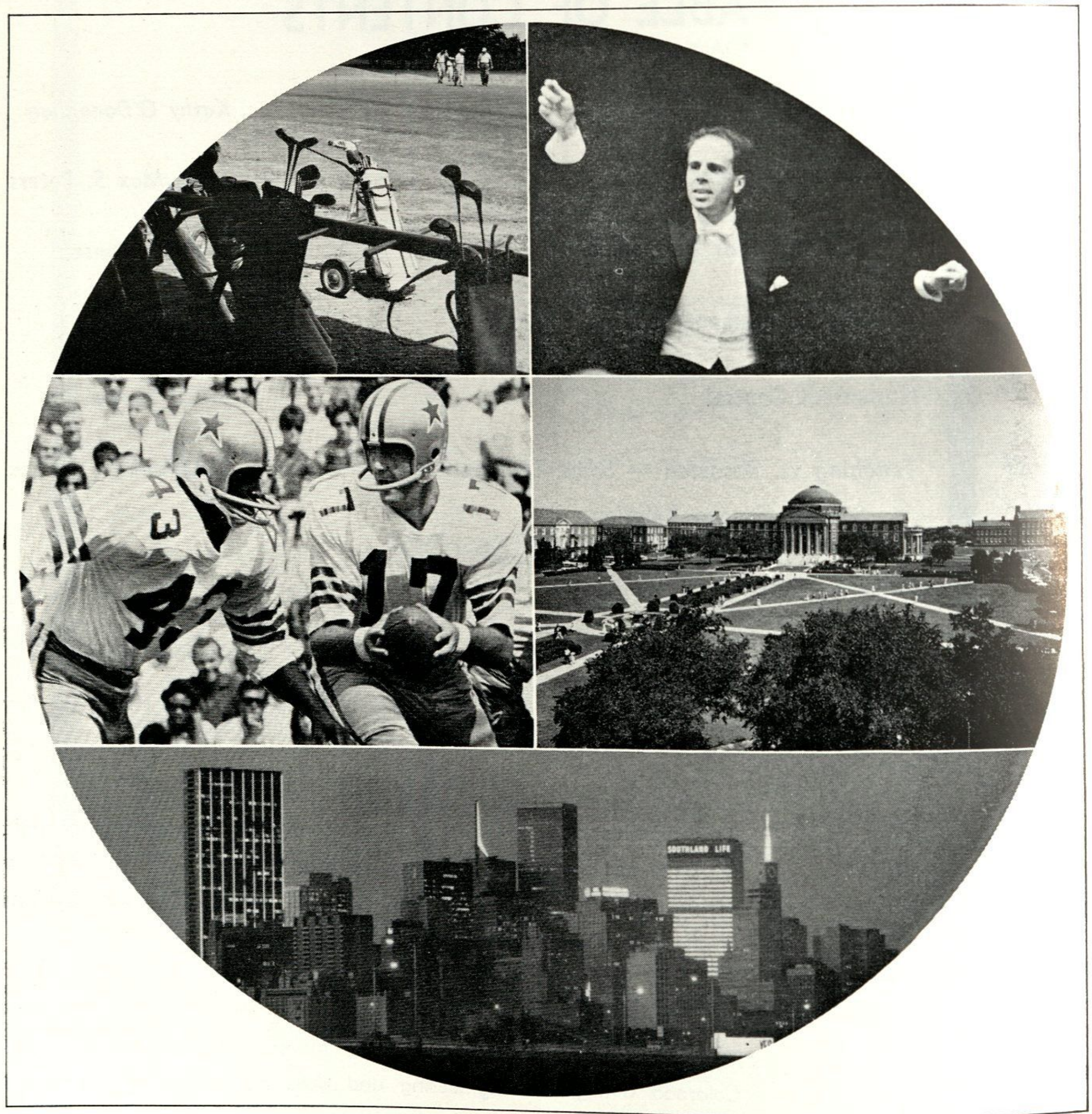


This month's cover by Steve Franek contrasts the general technology of North and South America. The problem of underdeveloped nations is discussed in "A Technology for Development" by John R. Hansen, beginning on page 14.

The Colorado Engineer is published by the students of the University of Colorado College of Engineering and does not necessarily reflect the opinions of the faculty and administration.



SOUTHLAND LIFE

EDITORIAL:

THE SPIRITED ENGINEER

With E-Days, we once again hear cries of "Where is Engine School's spirit?" "How can we show the 'other side' of the campus, the group that lives on the Hill, that we're here?" "We've got a new building—let's build some new traditions." O.K. So what?

Just this. Engine School has spirit—lots of it. No—not the kind that shows up at a rally or a function. It's better than that. It shows up in classes, in labs, in dedication to the study of reinforced concrete beams and chemical plants, of integrated circuits and linkages, of guidance-control systems and wave guides. It's quiet, subtle thing, but the excitement it generates is well-known to every member of Engine School.

And it is this excitement, premeating the walls of our new building as it did Ketchum and Hunter and Engineering I, that shows we are here. We haven't time for loud demonstrations of spirit—we've got more important things to do.

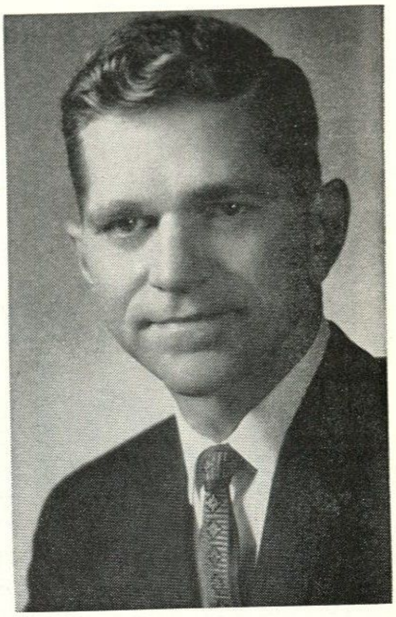
And it is this feeling that is the only true tradition that Engine School has—or needs.

—Kathy O'Donoghue

Photograph at left by David Lester.

DEAN'S COLUMN:

"I AM AN ENGINEER"



DEAN MAX S. PETERS

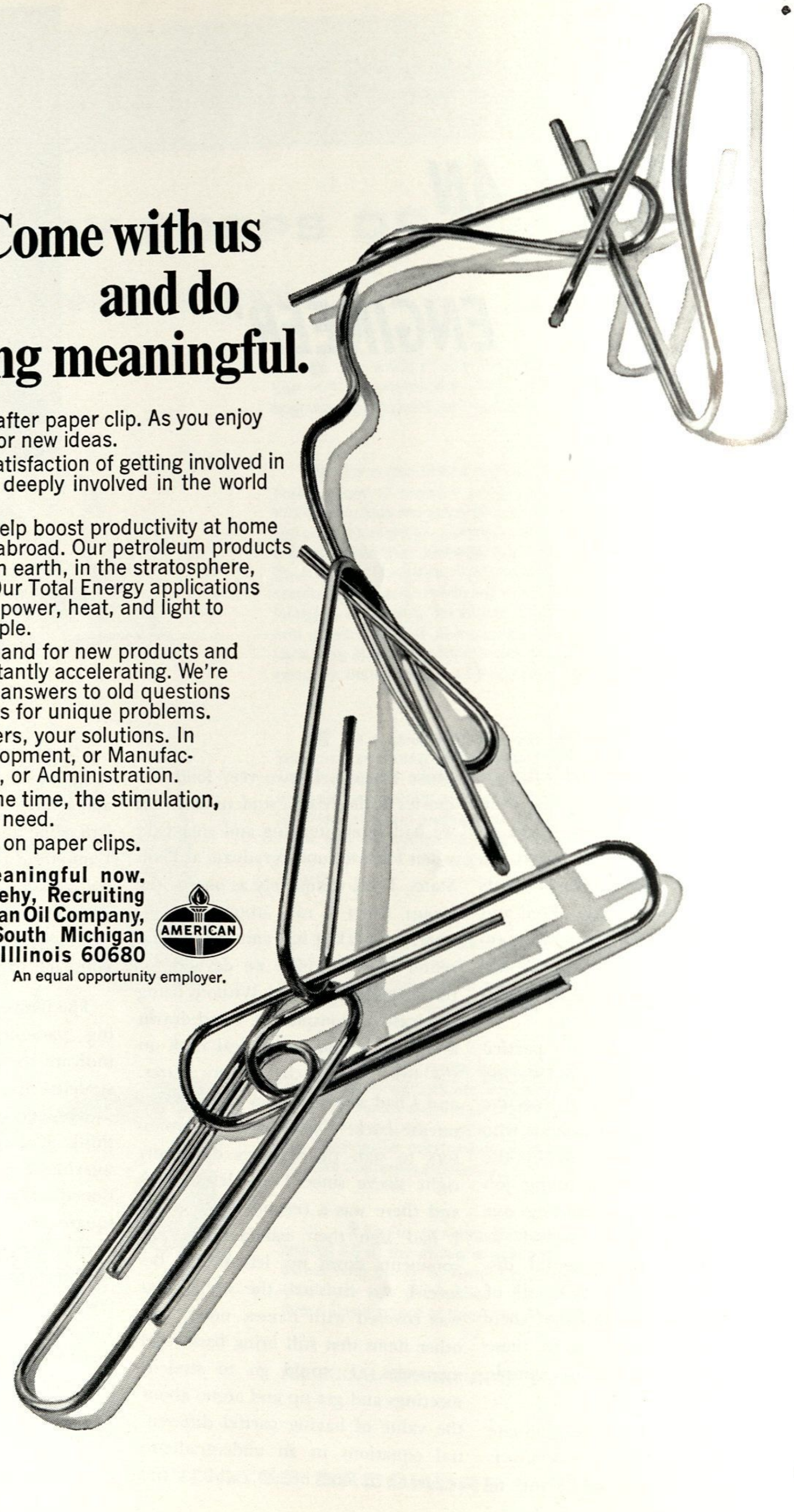
I have been very pleased with the approach Fred Stoppelkamp has been using as president of A.E.S. in an attempt to encourage more direct involvement of our engineering students in activities for our College. Fred and the Control Board have, in my opinion, the right ideas about what should be done in a real College of Engineering to develop student spirit.

For instance, 65 students participated in our recent Engineering Career Day for the 378 prospective high school students and parents who attended. Cards handed in by the visitors told of the outstanding job our students did in promoting our college. Our students served as guides, presented departmental displays, and served on panels—all of which required many hours of their time. My compliments go to these students who are setting an example for others to follow.

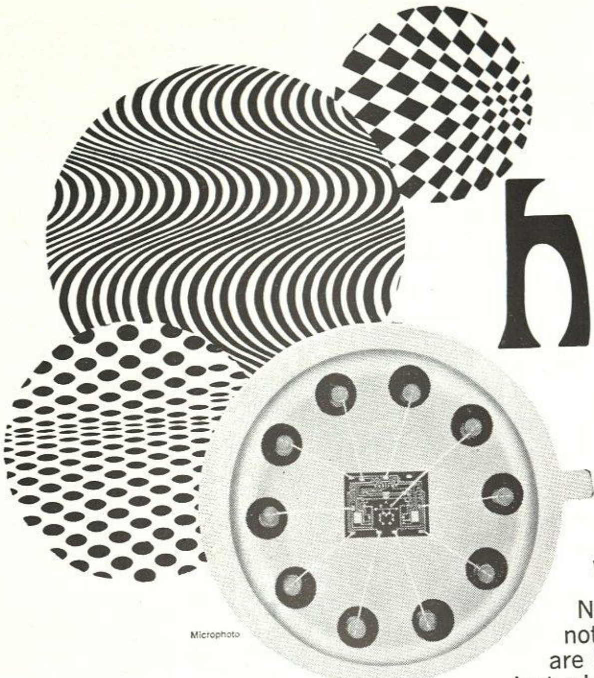
Student spirit in an undergraduate student body at a major university is very difficult to analyze. Just to prove my age, I have very fond memories of the type of student activities we had in engineering and chemistry when I was an undergraduate at Penn State. I felt completely as one of the group when I ran around campus wearing my key hat and our special senior blazers which we devised for the chemical engineers. Without being the least bit conspicious, I had drawn a slide rule and a chemical flask on the front vest pocket of my blazer, and I had a pair of track shoes drawn on the back. I permitted the professors to sign their names down my right sleeve since I am lefthanded, and there was a certain select group I had sign their names and their comments down my left sleeve. Before I was finished, the whole coat was covered with names, notes, and other items that still bring back fond memories. I would go to student meetings and get up and argue about the value of having partial differential equations in an undergraduate program in one breath, and in the next breath I would be complaining about the fact that my seat at the football game was not on the 50-yard line. I am afraid these ideas are completely out of date now, and I think our student body is missing much of the fun that goes along with this relaxed approach to student activities.

The items mentioned in the preceding paragraph would immediately indicate to many of our present-day students that I must have been totally square, and no modern student would think of doing this sort of thing or wearing the type of apparel mentioned. I really wonder what is so square about being willing to show outwardly a few emotions and even wearing a picture on your front vest pocket to advertise with pride that you are an engineer. In my case, there was special pride because I was advertising that I was a chemical engineer. You should have seen some of the fancy drawings the electrical

(Continued on page 12)



CONSUMER PRODUCTS ★ COMMUNICATIONS ★ SEMICONDUCTOR PRODUCTS ★ GOVERNMENT ELECTRONICS ★ AUTOMOTIVE PRODUCTS ★ CONTROL SYSTEMS



hip chip

What is it?

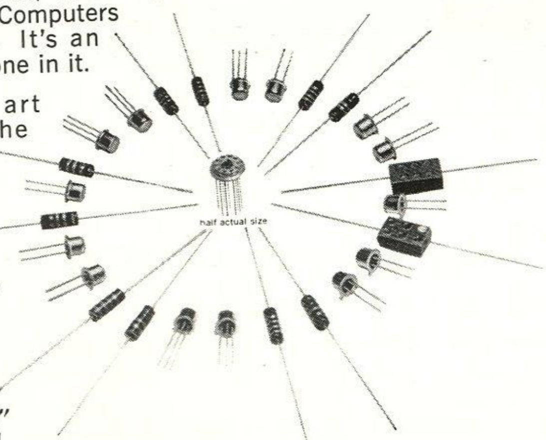
Not the op art discs — we're not about to describe them. We are interested in the micro-photo just above — specifically the little rectangle in the center. It's a minuscule chip of silicon produced in Motorola's semiconductor labs—on the verge of creating a scientific revolution all its own.

The chip's dimensions are 0.060" by 0.080"—about the size of a baby B-B. That tiny area incorporates 14 transistors, 10 resistors and 2 capacitors—performing the same circuit functions as the 26 discreet components shown below. It's Motorola's chip off a new block of electronics—it's an integrated circuit.

But why all the fuss?

Because the integrated circuit is the key to untold electronics marvels, hitherto impractical. Because its small size, weight, and power consumption lessen the cost of complex systems and improve performance. Because it's more reliable, to boot.

Integrated circuits already are used in design plans for amazing new computers — computers which will, in effect, function as special extensions of the human brain. Computers which, in time, will almost think. It's an exciting business. It challenges everyone in it.



Within a year, the solid state art will develop the means to store the content of the Encyclopaedia Britannica in a one inch cube—a solid state memory system. One day, every important university library will have electronic knowledge banks connected, perhaps by satellite, for instant exchange of information.

People generally are impressed by the chip with 26 components. But hang on. We've now got one in the lab not much larger (0.120" by 0.120") . . . **with 524 components!**

Hip chip? You bet.

TRUST THIS EMBLEM WHEREVER YOU FIND IT

MOTOROLA

(*Continued from page 9*)

engineers used to prove there was nothing as good as an electrical engineer.

Perhaps one of the reasons we do not currently see the outward indication of what I like to call "student spirit" is that our modern students often are searching for the right clever words. Too often, the clever words involve some sort of cynical attitude. One typical example is the oft-repeated complaint I hear that our professors are too much interested in research and not sufficiently interested in their teaching. I wonder if this really holds water. Certainly, our professors are interested in their research. I contend that an engineering faculty must be active in research if we are to be able to provide a modern undergraduate program and meet our other educational responsibilities for the state. There are cases where some professors become so involved in their research that they do not pay adequate attention to their teaching and their students. We try to spot such cases as soon as possible and correct them, but I dare say these are rare.

From my observation of our faculty and the faculty at other universities, the majority of the faculty members are strongly interested in teaching and in their students. Last spring I sent out 1,300 questionnaires to our seniors, graduate students, and former seniors and graduate students in engineering, asking them to let me know what they thought about the teaching at the University of Colorado, and requesting specific comments about individual courses. I received less than 100 responses (about a 7% return) and concluded that the students probably regard our teaching as satisfactory. If it were otherwise, I am certain our students would be anxious to help improve the situation by constructive criticism.

Our faculty is making every effort to do the best job we can for our students, undergraduates and graduates. We are always delighted to have input from our students as to our activities, and I would like to see more input from our students into direct student involvement in engineering affairs and other activities that would be related directly to the "student spirit" in the College of Engineering. As I have indicated before, it is clear I must be old-fashioned, and it is totally obvious that I am what you might call a "square" because I would be delighted to walk around campus wearing an orange cowboy hat, telling everyone that I am an engineer. As a matter of fact, I am so square and old-fashioned that I shall end this little sermon by saying ". . . I am a engineer—I am a chemical engineer—and I am proud of it. . . ."

Max S. Peters

Dean

A TECHNOLOGY

JOHN R. HANSEN

Throughout the impoverished areas of the world there are people who look with marvel and envy at the gleaming skyscrapers, glistening automobiles and shining modern factories, all of which form vital parts of the America of today. It is indeed an object of legitimate envy, for back of this gleaming façade lie the characteristics which, for most people, rich and poor alike, make life both human and enjoyable—a long life span, good health, and the material goods and gadgets that release people from the drudgery of existence to pursue the higher quests of life such as music, literature, art and the many other facets of culture—culture that is beyond the reach of the peasant working from dawn till dusk hoeing his eroded plot of land, trying to scratch out a meager crop which will keep his family alive for a few more months.

How did the United States come to be the budding cultural center of the world? Many favorable factors have helped—our historical background, positive attitudes towards work and thrift, an isolated geographical location and abundant resources, wise leaders in the early years, a fortunate escape from the ravages of the World Wars.

But ask the man on the street why America is modern and gleaming. What will he say? He will probably give credit to the wonder twins of today—Science and Technology. And after considering the matter a moment longer, he would give credit to the men who created this great driving force—the scientists and engineers.

No one could argue with the tremendous impact science and technology have had on the development of our country, yet one might very well ask, "with all this great store of scientific and technical knowledge available, why haven't the underdeveloped countries of the world borrowed some of this know-how and become developed as we have?"

A complete answer to the question of underdevelopment would be long and involved, ranging over a wide realm of disciplines—history, sociology, psychology, political science, geography and many others. Here we must content ourselves with one small, but very important facet of the answer: The technology that has made the United States what it is today just doesn't work nearly as well in other parts of the world. Why? Don't the laws of physics, and therefore the laws of technology, apply just as much on the other side of the world as on this?

The laws of physics certainly do apply, but physics and physical processes alone don't make a country develop. These processes—scientific and technological—must take place in the context of human society, and the conditions of human existence virtually defy all attempts at universalization.

As a result, any technology which is used in a country must be adapted to the needs of that country before it can become an effective force for development. Here lies the failure of American technology in many of the underdeveloped countries of the world.

The Two Types of Technology

The technology we know so well was developed here in the United States to meet the needs of a society where labor is scarce and expensive compared to the abundance of other natural resources; consequently it tends to be a *labor-saving* and *capital-intensive* technology. The goal of the American engineer may be called efficiency, automation, or many other things, but whatever it is called, it almost always results in getting the job done better with less expenditure of labor and with comparatively little concern for the cost of the machinery required. The capital expenditure has grown by leaps and bounds, while the increase in the labor force has been only gradual. As a result, the capital at the disposal of each individual worker and the production per man have grown markedly over the past few decades.

This trend is fine in a country where labor is a scarce resource and capital is plentiful. But this technology just isn't appropriate in a country where labor is overwhelmingly

FOR

DEVELOPMENT

plentiful; the last thing these countries need is an expensive machine which will do the same job with fewer men. This would not only fail to solve the presently acute problem of unemployment—it would aggravate it. What is needed instead are new methods which rely more heavily on the additional use of men than of capital. In other words a *labor-using* or *labor-intensive* technology is needed.

It sounds strange to talk of technology which uses more, not fewer, men, for we are so culturally acclimated to the capital-intensive type of technology that we think of labor-intensive technology as the antithesis of "real" technology. It sounds as though the best example of a labor-intensive technology would be the caveman who relied almost entirely on his own labor, having an extremely limited stock of capital equipment—perhaps a stone ax, a shell scraper, a rough spear, and a few other rudimentary tools.

When economists cry out the need for a labor-intensive technology, they are not suggesting that the underdeveloped countries return to more primitive forms of technology. On the contrary, they recognize that a lot of capital indeed must be invested if progress is to take place. They only are asking the innovations place more emphasis on the saving of capital and less on the saving of labor, reversing the emphasis found in the United States.

Capital and Labor

The lack of capital in these countries stems from a variety of social and historical conditions. Looking at the problem as a whole, one can say that "poverty breeds poverty" is the basic explanation. These countries are trapped in a vicious circle of poverty and cannot escape. The circle goes like this: The people are poor and therefore can not save; they consume all of their meager sustenance and none is left over for investment. With no investment there is no progress, no new jobs. And without jobs and improved production, the people remain in their perpetual state of poverty. And the circle goes reeling on through another cycle.

There are of course many side effects or epi-circles to the vicious circle of poverty. The epi-circle of health dictates that when people are poor, they can't eat properly and do not get the proper medical attention. As a result their productivity is much below that of their well-fed brethern in the more developed countries, or they become so sick they can't work at all. In either case the vicious circle of poverty continues as partial or total unemployment helps drive it along. Capital accumulation under such conditions is virtually impossible.

Another epi-circle is that of social overhead capital or infrastructure. Capital and investment are not attracted to the improverished countries because they lack the roads, electric power, communications systems, water supplies, educated labor force, good schools, organized marketing system and many other types of infrastructure which support and make profitable the operations of individual corporations in the more advanced countries. New investment naturally gravitates towards those areas where industrialization and commercialization are already well under way—where the social infrastructure has already been built up. The underdeveloped countries are left out in the cold, and without new investment flowing into these already improverished countries, there is little stimulus for these regions to develop the necessary infrastructure, and the vicious circle begins again. And with each cycle, the gap between the developed and underdeveloped regions increases, ever lessening their chances to develop the infrastructure necessary to break out of this vicious circle and start up the long and tortuous road of development.

It can be seen thtat there is a real need for development of a technology which is capital-saving, for very little capital can be saved and invested in countries trapped in the vicious circle of poverty, and what capital there is has been shipped abroad due to lack of incentives and opportunities for investment at home.

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Though a capital-saving technology would represent a great step forward, there is also a need for the technology to be labor-intensive. A majority of the currently underdeveloped countries of the world are suffering from a population explosion. This means not only more mouths to feed, but more hands to keep busy.

It might be possible to feed the population if massive investments were made in heavy agricultural machinery and in plants for the synthesis of artificial foods, but this approach is impossible given the current systems of land holding, the topography of many countries, and social customs and traditions. Perhaps even more important, though this would allow large populations to be fed, it would at the same time throw the small peasant farmer off his plot of land, and as he and his family migrated, along with thousands of others facing the same fate, to the urban areas hoping to find employment there, teeming slums would arise, and the social tensions bred in this squalor could easily destroy all pretense of social order. Without the security and efficiency of a viable, orderly social structure, no new investment would come in, and the investment already present would flee as starving mobs stormed the factories demanding work and food.

No, it will not do to send our beautiful Caterpillar tractors and our glistening combines to these countries. This will solve neither their food problems nor their employment problems.

What is needed instead is forms of technology which will create more jobs for more people. Make-work jobs are of comparatively little value here. Real jobs which produce badly needed goods and services must be found instead, jobs which can employ large numbers of people productively.

Interaction of Labor and Capital

The problem of excess population ties in directly with the lack of capital for investment in these countries, for with rapidly expanding populations, large investments must be made simply to maintain the present standards of living. More money must be spent on schools, hospitals, housing and roads simply to take care of the expanding population. This capital widening does not contribute to economic progress and an expanding prosperity within the country, however. This comes about through capital deepening—increased capital stock per inhabitant of the country. With capital deepening, every worker has more capital equipment to work with and can produce more during every working hour. This rise in productivity raises the standard of living of the country and helps it break out of the vicious circle of poverty as more can be saved and invested.

We have seen the twin problems of the underdeveloped countries—too little capital and too many people. The next question is, "How can the little capital that is now available (or that will become available) be made to go farther? How can this capital be used to gradually increase the productivity of almost all of the workers rather that simply to jump the productivity of a very few workers, in the process throwing hundreds of others completely out of work?"

Labor Intensive Technology— Its Nature and Limitations

Let us return to the question of what is meant by a labor-intensive, capital-saving technology. We have already recognized that new technology can not be implemented without expenditure of at least some capital. Money will of course be spent, but the idea is to develop a technology for increasing production and productivity that will substitute as much labor as possible for capital, a goal diametrically opposed to the goal of technological development in the United States.

A distinction should be made here between capital-saving *inventions* and capital-saving *innovations*. The airplane, for example, is an invention that allows a much lower expenditure of capital per ton mile of freight than does a railroad train and can therefore be called a capital-saving invention. However, the innovation of air freight, the actual investment of capital to establish an operating system of airlines which can carry freight throughout a country is terribly expensive. Though in the long-run considerable capital is freed from the transportation sector for use in other sectors of the economy by the introduction of airplanes, in the short-run almost prohibitive amounts of capital must be invested to make the invention operable—the innovation *per se* is definitely not capital-saving. Engineers seeking to develop technology suitable for use in developing countries must be conscious not only of the long-run savings of capital possible, but also of the initial costs of introducing the new technology—the costs of innovation.

Engineers and scientists seeking to develop a labor-intensive, capital-saving technology should also be wary of false economization of capital. For example, having several hundred women working by hand looms to weave a given quantity of cloth instead of investing several thousand dollars in a couple of large modern looms might appear to be a saving of capital. However, when one considers the money costs of wastage of materials by unskilled labor, loss of markets due to inferior goods, and the costs of maintaining large inventories of new materials tied up in the long and tedious process of producing cloth on the hand loom, it may well be that the modern machines actually cost less in the short-run as well as in the long-run and should be installed.

The Development of a Labor-Intensive Technology

Engineers should not become discouraged by the black picture painted above of developing countries' inability to invest and their acute need for labor-intensive forms of technology, for much can be done to remedy the situation.

For the scientist or engineer willing to accept the challenge of developing technology suitable for the underdeveloped nations, several paths lie open. Among the most promising appear to be the modernization of older machines and processes, the reduction or "householdization" of industrial tools, and completely fresh approaches to old problems.

But as the inventor follows one or more of these paths, let him keep in mind the following criteria which must be met if his invention is to be a truly useful weapon in the international war on underdevelopment

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and poverty: The invention should (1) be capital-saving, (2) be labor-intensive, (3) stimulate or make possible the economical substitution of locally produced goods for imported goods, (4) make use of raw materials available within the country, (5) use labor skills available in the country or ones easily mastered by relatively uneducated people and (6), perhaps the most idealistic of all these criteria, the invention should stimulate the growth of other complementary industries and the development of social infrastructure.

With these criteria firmly in mind, the engineer can follow the path that suits his abilities or fancy. Suppose he takes the first. The modernization of older machines and processes holds considerable promise, for over the years many methods of doing things have been developed which were very good at the time, but were soon superseded by more advanced technology and forgotten. Many of the machines abandoned in the United States have been sent to developing nations where they are well suited to the local needs. The availability of used machinery has been a big help to these countries, but there is a limited number of old machines left, and many are beyond repair.

Computers Won't Do

Strange as it might sound to suggest manufacturing today looms or lathes or other machines that were originally built 25 to 75 years ago, these could be used to great advantage in countries which are still striving to reach the level of technological sophistication which produced these machines so many years ago in our own country. These countries don't want big computer-programmed, continuous-weaving looms; a small, semiautomatic machine would be a great improvement over the hand looms they are currently using and would meet their needs for a good many years to come. This process of manufacturing old machinery again sounds simple, so ridiculously simple in fact as to insult the intelligence of any trained, sophisticated scientist or engineer. Here though is the catch; here is my challenge to the engineer: Take the new materials, the new manufacturing processes, the refinements of design, the cost-cutting techniques that make today's machines so efficient and economical and incorporate them into the machines of yesteryear. Yes, I agree, many times this may seem impossible, or the end result may appear to be a machine virtually identical to those today, but the challenge is to incorporate these modern features while at the same time maintaining the original levels of capacity, cost and simplicity. If this is done, machines will be available to the underdeveloped countries at a much lower cost, and these machines will better meet the needs of these countries than the most modern of machinery will, no matter how attractive it may appear.

Householdization

The second line of approach I have suggested holds many fascinating possibilities. Within the past few years there has been a startling revolution in the United States. I have called it the "householdization" of industrial tools. This revolution was stimulated in large part by the handyman movement in our country. Scores of household tasks and minor repairs which were once done by the village jack-of-all-trades or the domestic servant began to be done by the homeowner and his wife as unskilled labor which worked as domestic help became scarce. To take on all these tasks would have been unthinkable, even impossible, had it not been for the "householdization" of industrial tools —saws, food mixers, sweepers, mowing machines, and many other gadgets common in households today which were once found only in large institutions such as factories, restaurants, hotels, and garages in much larger and more expensive form. However, during the past decade or two, scores of these tools have been scaled down both in price and in size so that they are available to the ordinary household. The modern American household is a veritable factory in miniature with all its gadgetry.

What does this have to do with the underdeveloped countries? This process can be both paralleled and expanded in the evolution of technology for the developing nations. Take the most modern and sophisticated of machines or processes and scale it down, both in size and cost, to the needs of a smaller producer. In many cases the same kind of equipment you and I find around our homes in the garage or the kitchen could find its way into a small business or factory in another part of the world and meet a real need. This should be encouraged, for this type of technology these people can use; it is comparatively inexpensive (capital-saving), it uses more labor than other more elaborate and sophisticated methods (labor-intensive), yet it is more efficient and more productive than the primitive ways currently in use (it helps raise the standard of living, increasing the opportunities for increased saving and further investment).

The third path I have suggested is probably the most exciting, yet at the same time the most poorly defined. The only guideposts here are the six criteria mentioned above; there are no designs to copy and adapt as in the first two cases. To follow this path requires not only great imagination and an inventive genius, but keen insight into the problems faced by the underdeveloped countries. Those who chose to follow this path will inevitably find that it leads them directly into the countries where the problems arise. These problems can be only vaguely surmised from the distance; to really know them and to seek out realistic solutions requires a first-hand knowledge of the situation, the resources available, the bottlenecks, the cultural traditions and mores. I can only point in a general direction for those who choose to strike out on their own in totally new approaches to problems both known and unknown. Those who accept the challenge must explore what lies ahead on their own.

Positive Projects

For those to whom this paper has seemed too idealistic and abstract Figure 1 contains a sampling of positive proposals for action on specific projects, projects which challenge the ingenuity of each and all of the various fields of engineering. Though the projects are classed under several specific fields of engineering, the general interdisciplinary nature is obvious. (See pages 20-21).

(*Continued on page 24*)

Agricultural Engineering

1. Jungle Soil Technology: The soil of jungles is notoriously poor for raising crops on a long-term basis, inspite of the lush vegetation which it supports in its native state. Work needs to be done to devise methods of controlling the leaching of the fertility of jungle soil and the water content of the soil. Someone needs to develop fertilizers which will not wash out under these conditions, yet be economical enough to use, and to create breeds and species of plants which will survive better than those currently available. These projects are very important considering that most of the underdeveloped countries lie within the tropical zone of the world, and many of them have jungle or semi-jungle conditions.

2. Dry Land Technology: Though many of the underdeveloped countries have tropical and jungle areas, others suffer from exactly the opposite problem—they have large expanses of desert or land so dry that crops won't grow. Better systems of pumping water, controlling soil movement, retention of surface and subsurface water, and of growing crops under these conditions would be a great boom to these countries.

Architectural Engineering

1. Housing Designs: The population explosion of the underdeveloped areas has caused an acute shortage of housing. Low-cost housing is of course available if one could consider primitive construction methods like wattle and daub or thatch, but these methods are inadequate for urban areas; they are too unstable and unsanitary. Architects need to devise completely new designs of construction which will be fast, simple, standardized, and sound.

2. Methods and Materials: There is not only a need for better designs, but also for better methods and materials. The geodesic dome, prefabricated components, modular plumbing and integrated electrical systems are all possible cost-cutting and simplifying approaches.

Aeronautical Engineering

1. Helicopter Development: Many very fertile and potentially productive areas in underdeveloped countries lie uninhabited because they are too far from the centers of population and lack adequate access roads. Improved helicopters (cheaper ones, more reliable ones, and simpler ones) could be of great aid in opening up these regions, not only by supplying the road crews with needed supplies and machinery, but by flying out produce to markets until an adequate transportation system was completed. If helicopters were improved, they would also find much wider use in developing the infrastructure of the poor countries—stringing electric and telephone lines, setting poles in rugged, inaccessible country, etc. Currently initial cost and maintenance expense for helicopters prohibit this.

2. Development of Low-cost Cargo Planes: The DC-3, old as it is, still is very popular in many parts of the world because it is cheap and reliable. Soon the last of these will be gone, and the supersonic transport certainly won't replace it, not with the primitive landing fields available in these areas. Aeronautical engineers should turn back for a while and develop, with all the modern technology now available, low-cost cargo planes which will fill the gap between initial helicopter transport and later heavy commercial traffic between the now remote areas and the urban centers.

Atomic Engineering

1. Earth Moving: Operation Plowshare was designed to explore the potentialities for peaceful use of the atom, but so far the technology is not sufficiently advanced to allow small scale use of atomic blasts for such purposes as earth moving. Though it might not be as labor-intensive, atomic earth moving for roads in mountainous regions could represent a tremendous savings in capital expense and would greatly speed up the opening of new areas which would offer widespread opportunities for new employment.

2. Reservoirs: Subterranean atomic blasts could create underground reservoirs capable of storing large amounts of water during rainy seasons, water which could later be pumped out for irrigation during the dry seasons. In the meantime it would be much less subject to evaporation to the atmosphere.

Chemical Engineering

1. Fertilizers: Fertilizers hold the promise of fertility for presently unproductive lands, but present methods of producing fertilizers are still so expensive as to limit them far too severely in comparison with the need. New and cheaper methods of synthesizing fertilizers need to be devised.

2. Iron and Steel: One of the hallmarks of development progress today, at least in the eyes of the nationals of the underdeveloped countries, is the construction of a national steel mill. However, many countries lack at least one of the raw materials needed (iron ore, coal and limestone), making production excessively

Figure 1—Needed Developments in Engineerin

expensive. To take a particular example, Venezuela has good iron and limestone reserves, but lacks coal. It has already built a steel mill, but must import coal from the United States. If a new technology could be developed using the carbon from the extensive petroleum reserves of Venezuela instead of from imported coal, tremendous transportation costs could be saved. This approach might also be used in the oil-rich Middle East.

3. Building Materials: Chemical engineers could cooperate with the architects to develop new building materials which would make construction cheaper and more durable. Special attention should be given to the possibility of utilizing native materials and processing them into building materials as has been done in South America in certain areas where corn stalks and other fibrous materials are crushed and pressed into composition building board.

Civil Engineering

1. Road Building: There is a shocking lack of adequate roads in the underdeveloped regions. New technology needs to be developed to make the opening of roads easier, cheaper and faster, and systems must be worked out to stabilize road beds and surfaces so that the roads do not become impassable. Research needs to be done on the cause and prevention of washboarding of dirt and gravel roads.

2. Urban Design: As peasants leave the country seeking employment in the cities, the problems of slums becomes acute. Something must be done to alleviate the problems of inadequate housing and the spreading of slums like blight across the face of Latin America cities. Methods to make the extension of existing water, sewer, and electrical systems cheaper and more rapid should be developed.

Electrical Engineering

1. Communications: Many parts of the improverished countries are completely cut off from outside contact and hence stay in their ignorant, impoverished condition. There is great potential for microwave communication to these areas and perhaps even facsimile news media. There has been some argument that television is the next logical stage for these areas rather than newspapers, for teaching literacy can be a long and costly process.

2. Computers: The use of computers, although initially expensive, may well cut costs in many fields drastically and immediately. Collection of customs and income taxes is extremely difficult in most developing nations due in large part to the totally inadequate systems of accounting, record keeping and information retrieval. Systems should be devised for tax collection and tabulation within the country. A world-wide system for customs clearing, billing and shipment notification would help speed the international commerce which gives life to these countries. This system would also facilitate the collection of customs duties.

Mechanical Engineering

1. Transportation: As a country progresses through the various stages of economic development, the people require more and more mobility; they must get to markets with their goods, they begin to work farther from home, and as their horizons widen and their incomes increase, they begin to travel for pleasure. This increasing demand for transportation is met in a series of steps—a horse, a bicycle, inter-city trucks, then buses, and as income increases people begin to buy their own private motorized transportation—motorcycles and later, in the final stages of development, cars.

Many of the underveloped countries today are at the stage where motorscooters and motorcycles are becoming very popular. However, only relatively limited use is currently being made of these machines, for in addition to use as basic transportation, these machines with proper attatchments could become much more than a source of transportation; they could become a private supply of labor-saving mechanical energy for everyone who owned a motorcycle.

Some of these attachments already exist; many are yet unknown. It would be very interesting to see a mechanical engineer develop attatchments such as a small electric generator, a small irrigation pump, a power take-off drum to drive small belt-driven threshers, corn shellers and grinders, shop tools like lathes, drills, potters wheels, etc., and many other similar small attachments which would help to raise the productivity of the individual farmer working his small plot of land and help to make the duties of his wife around the home easier.

2. Land Clearing Equipment: Much of the underdeveloped world suffers from a shortage of usable land, and most of the virgin land is almost unusable because of the prohibitive costs of clearing it on a large scale. Though an American manufacturer has created some giant machines for jungle clearing, they are still more expensive to use than manual labor. If more work could be done to improve the efficiency and lower the cost of these machines, the benefits to the land-starved countries would be immense.

NEWS for 1966 1967 ENGINEERING GRADUATES

(Continued from page 19)

The projects are not all original; many of them have been thought about before, and some have already undergone considerable study, but all (at least to my knowledge) are greatly in need of serious work, for if developed they would be of great assistance in many areas of the world. On most, research will be needed; on the others, it may simply be a matter of getting the information concerning already known solutions to the country where the problems arise.

Most of the projects mentioned are fairly major undertakings which will probably require considerable time and effort. There are however hundreds of little projects which need attention and solution every month. An association based in New York State called the Volunteers for International Technical Assistance publishes a monthly newsletter which includes requests from all over the world for simple devices such as a hand-operated machine to weave light galvanized wire into chicken wire, a device to weigh children in health centers, a low cost grass inhibitor (herbicide), a palm tree eradicator, and information on simple industrial processes like auto muffler production, making tennis rackets, etc. This is only a sample of the many requests from only one month (October, 1966) of the *VITA Newsletter*. Some engineering professors have used these newsletters as a source of design projects for their students with very good results. A good example of a response to such requests was the design of a small tractor made primarily from parts of abandoned automobiles. The possibilities are virtually limitless—the challenge is waiting.

Meeting the Challenge

The challenge that faces engineers and scientists is the development of a technology that concentrates on using labor and saving capital as a start, and the introduction of this technology in the underdeveloped countries.

This challenge can be met in a variety of ways; domestic research and production, foreign research, development and investment, education, and international service are among the best.

Domestic research, development and production, guided by the needs of the developing countries, can produce many of the processes and tools needed for economic development of the poor countries of the world. This will require a new outlook and direction on the part of the companies doing this work, but I am not suggesting at all that this dedication of men and material is strictly a humanitarian venture. It can be justified in terms of hard cash, for the market for these products is waiting in these countries—they are willing to pay for goods that really meet their needs—and companies which begin investigating this field now stand a very good chance of financial success. An interesting example of a pioneering venture in this general direction is the International Basic Economies Corporation. Among its other ventures which involve projects to help economies develop, it designed a small hand-operated press which can make extremely hard and durable bricks out of ordinary dirt mixed with a very small amount of cement. These presses are in use all over the world and have had a big impact on housing programs.

The activities of the International Basic Economies Corporation overlap into the second general approach mentioned, foreign development and investment. IBEC has gone into numerous countries and established profit-making industries which are greatly needed by the local economy. Many other firms have been involved for years in investment in foreign countries, but far too often the investment has been more for exploitative purposes than in the interest of long-run development of the country. The firms which do engage in overseas investment have not only an opportunity but a certain responsibility to invest in ways that will be beneficial to the host countries as well as to themselves.

Opportunities in Teaching

For those who dedicate their lives to the teaching of the engineering sciences, there are many opportunities to help develop programs of technical and vocational education to fill the needs of the developing countries. The countries need good solid training programs in basic engineering, and on an even more fundamental level, in vocational education. Training manuals need to be written and courses need to be taught. Groups such as the International Executive Service Corps regularly handle demand for personnel to help with such programs.

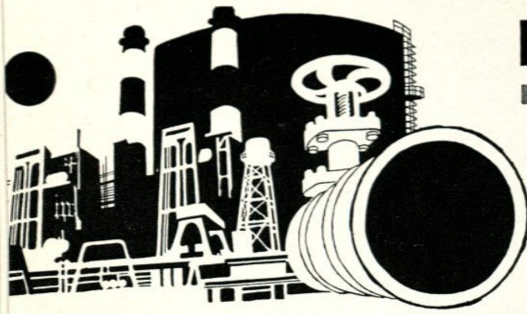
Though the previous three approaches have in many ways implied work abroad, the fourth, international service, calls for a direct and personal involvement in foreign countries, helping people in their own environment. The opportunities for international service for qualified engineers and scientists are very widespread; international organizations such as the Inter-American Development Bank, the United States Agency for International Development, UNESCO, the Peace Corps, the World Bank and many others continually need qualified scientists and technicians to assist in feasibility studies, specific project design, project management and other development work. Almost all areas of science and engineering are needed badly in the field of international technical assistance.

Conclusion

The technology which has been developed in the United States is often not very useful in the underdeveloped countries of the world, for it was developed in response to the need to save labor, and in these countries the need is to save capital; comparatively little importance is placed on the amount of labor used, for labor is very plentiful due to the vicious circle of poverty, lack of opportunities for investment and other social and historical factors.

There is a need for a new technology, based in part on our own technology and in part on completely new approaches, which will be labor-intensive and capital-saving. Those engineers and scientists who are willing to meet the challenge of developing this technology and of taking it to the underdeveloped countries have only to dedicate themselves to the task.

STATE



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Engineers may receive, as applicable to their specialties and interests, such responsibilities as:

Estimating

Assist in the preparation of estimates, cost control, and cost analysis of design and construction activities.

Engineering

Assist in development of process design, flow diagrams . . . Prepare piping and instrument diagrams . . . Calculate heat and chemical balance, mass transfer and fluid flow . . . Size equipment . . . Write specifications . . Requisition equipment . . . Design circuits, power distribution systems, lighting and instrumentation . . . Prepare design sketches, drawings or portions of construction plans.

Construction

Plan and schedule field work in close cooperation with project superintendent . . . Inspect equipment as received and after installation . . . Perform quantity take off for equipment, concrete work, structural steel, instruments and piping, electrical conduit and wire. On the basis of this information make preliminary manpower forecasts . . . Read, review and follow job specifications and drawings.

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TAU BETA PI ESSAY:

SOCIETY, GOVERNMENT AND THE ENGINEER

JACK QUENTIN REES

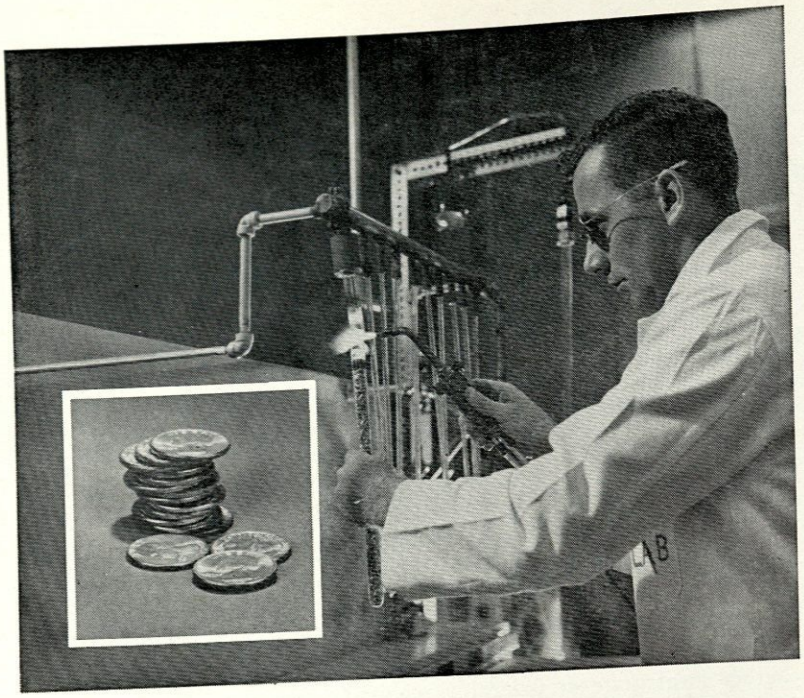
Air pollution, water pollution, auto and highway safety, urban sprawl and decay—each of these is a glaring social issue and each of these is the result of technological changes fostered by engineers. Therefore, do not engineers have the ethical and moral responsibility for these problems and others resulting from the technological changes they introduce into society? The answer to this question has been a rather unresouding yes from the engineers—unresounding because the admission puts engineers in the position of scapegoats for technologically uninformed political decisions. And herein lies the paradox, engineers have the responsibility for these problems but lack the authority to do anything about them—a rather uncomfortable position! Aside from the discomfort suffered by the engineers, these uninformed decisions can conceivably have the cumulative result of endangering the very existence of our society.

These considerations seem to leave little doubt that engineers should become active in government. Now the question is, in what capacity? Are they to be advisors, administrators, or decision makers? At present there are many engineers in governmental advisory and administrative positions, but few in a position to have any say in the decisions made by the government, whether local, state or federal. And those that are in a position to push for technically sound decisions seldom have the organized backing necessary for serious consideration of their criticisms and proposals. In short, I am saying that engineers are needed in voting positions in community, county, state and federal government, and that these engineers must have the backing of the engineering profession.

The backing of the engineering profession alone, however, will hardly be sufficient to bring about this transition of the engineer from an advisory to a decision-making position. This transition will also require the support of the various other professions and of the general populace.

Perhaps one of the main steps in gaining the support of these bodies should be the destruction of the image of the engineer as a technically competent, but uncultured and socially uninterested gadgeteer. This could be done by drawing public attention to engineers who are also artists, writers or musicians and who are active in public affairs; and by increased encouragement from engineering societies for participation by engineers in these activities. In addition, a joint professional council comprised of physical, medical and social scientists, engineers, businessmen and lawyers could provide a means for interdisiplinary discussion of the need for technically informed people in government and could also provide a means of disseminating interdisiplinary information to the various professions. This type of discussion and dissemination of information could also be provided by the engineering societies' encouragement of local radio and television forums and university discussion groups.

The growing technical complexity of our society and the effects of this technical complexity upon our society require that engineers take a greater role in the decision-making aspects of government. In order to do this, the public, the engineers and the other professions need to be awakened to two main things—technically uninformed decisions are becoming more and more dangerous to society, and engineers are competent both socially and technically to handle decisions affecting the public well-being. Hopefully, action now by the engineers and their societies can bring under control and eliminate those social problems for which they have the ethical and moral responsibility but which they currently do not have the authority to solve.



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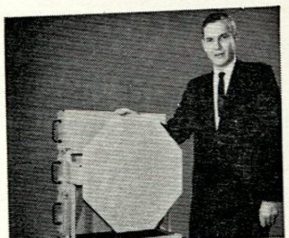
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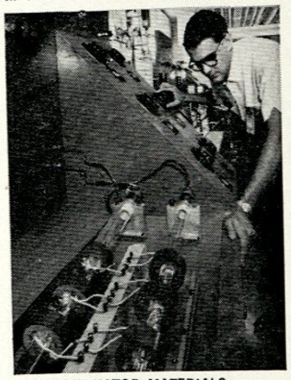
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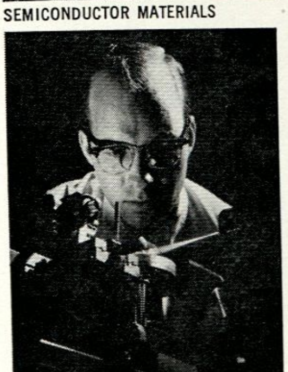
COHERENT OPTICS

NUMERICAL CONTROL

BRUCE BEYERS

The Electronic Industry Association defines numerical control as "a system in which actions are controlled by the direct insertion of numerical data at some point. The system must automatically interpret at least some portion of this data." However it usually is assumed to be a versatile means of automatically controlling machines through the use of punched or magnetic tapes. This does not mean that numerical control is a new form of automation which can be used only in the production of large quantities of parts. This is exactly what numerical control is not. Instead it provides the means of producing only a few parts economically.

There are two basic types of numerically controlled machines, point-to-point machines and contouring machines. At the present time, point-to-point machines are the most extensively used, but because of advances in this field, contouring machines are rapidly becoming important.

As the name implies, the use of point-to-point machines involves a process by which the tool is positioned over a certain place on the workpiece and then the operation is performed. After the operation has been completed the tool automatically moves to the next position. Since the tool does nothing to the workpiece while moving from one point to another the path it takes is immaterial, providing, of course, that the tool does not collide with the part or the holding fixture. Usually the path taken is such that a minimum amount of time elapses during the traversing period. Examples of such machines are drill presses, boring machines, punches, spot welders, and riveters.

Method of Control

One interesting thing about position control which is easy to understand is the method of punching instructions on a tape. A point in one dimension is usually controlled by a 4x4 dimensional array (providing measurements are made in thousandths of an inch). The columns of the array are given the following values:

column	1	2	3	4
value	1	2	4	7

The first, second, third, and fourth rows are for the units, tenths, hundredths, and thousandths place respectively. A value for one of these places is obtained by summing all the values punched in that particular row.

For example, suppose we had the value x=4.239 inches. The punched tape would be made up as follows:

first row—punches in third column

second row—punches in second column

third row—punches in first and second columns

fourth row—punches in second and fourth columns. (See Figure 1.)

As opposed to point-to-point control, in contour control the tool works on the part all the time it is moving. The entire travel must be controlled, both as to position and velocity, and therefore contouring machines are more complicated and expensive. Some examples of this kind of machine are profilers, lathes, milling machines, grinders, and torch cutters.

Because of its special characteristics

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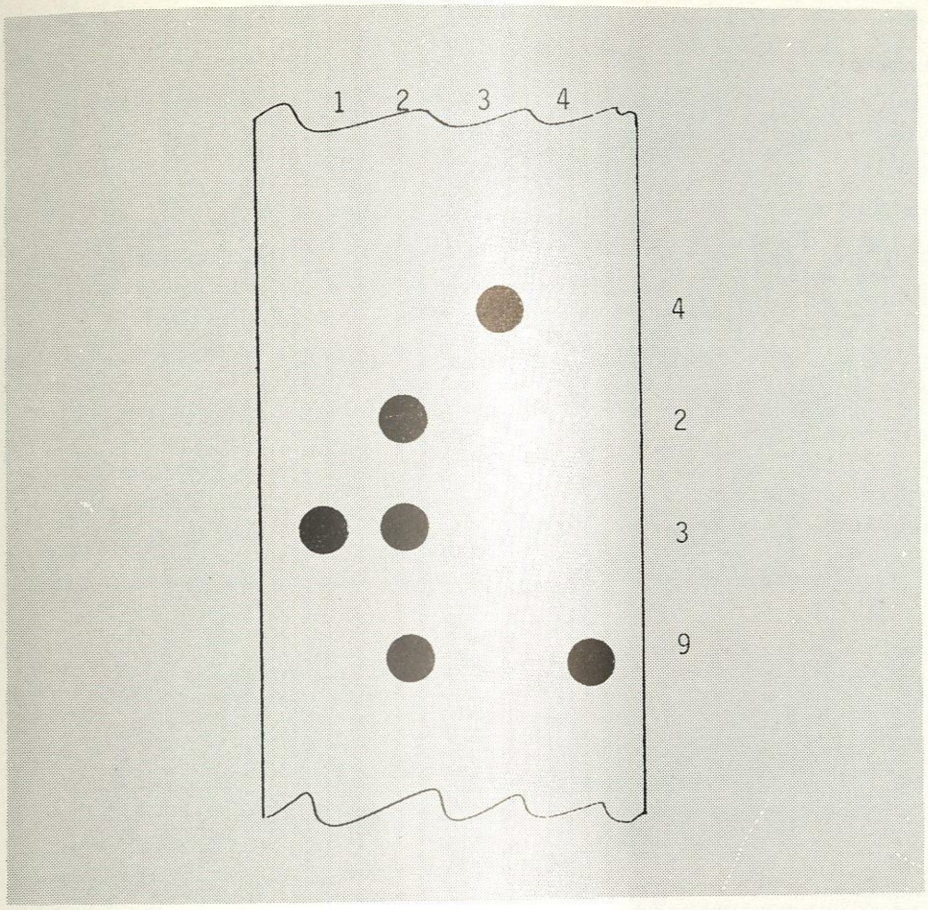

Figure 1 — Segment of punched tape used for control.

(Continued from page 29)

several things must be taken into account when a contouring machine is being programmed. These are:

1. The contouring machine must be capable of moving along a specified path with the required precision.
2. Side forces on the tool are more severe in contouring.
3. The data fed into the machine for contouring must be carefully planned so that the machine will not be called upon to make sharp turns or sudden stops where accuracy is important.
4. The size and shape of the cutting tool must be taken into consideration while writing the program.

Data for the control of a contouring machine can be presented in several ways: the coordinates of each

(Continued on page 33)

Order number	Coordinates	Meaning
3	$r_2\ (x_1,y_1)$	Drill hole radius r_2 at (x_1y_1)
1	(x_2,y_2), (x_3y_3), (x_4,y_4), (x_5,y_5), (x_6,y_6)	Starting at (x_2,y_2) mill a faired path through the points given to (x_6,y_6)
2	(x_7,y_7)	Cut a sharp corner at (x_6,y_6) and mill a straight line to (x_7,y_7)
5	(x_8,y_8), r_3	Mill a circle of radius r_3 to (x_8,y_8)
4	(x_9,y_9), A,B, C, D, E	Mill a conic section with parameters A,B,C,D&E to (x_9,y_9)
2	(x_2,y_2)	Cut a sharp corner at (x_9,y_9) and mill a straight line to (x_2,y_2)

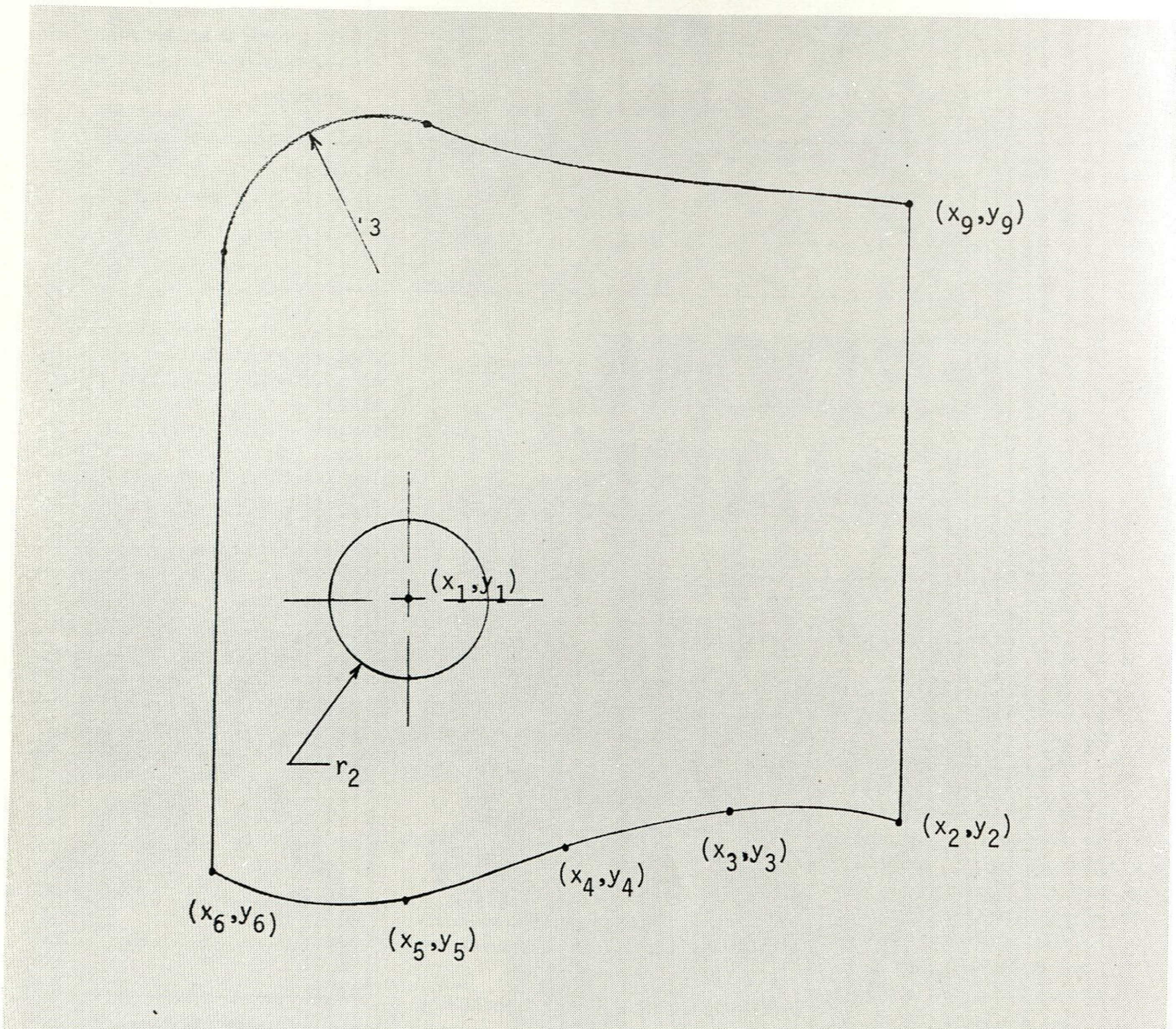

Figure 2 — The program explained

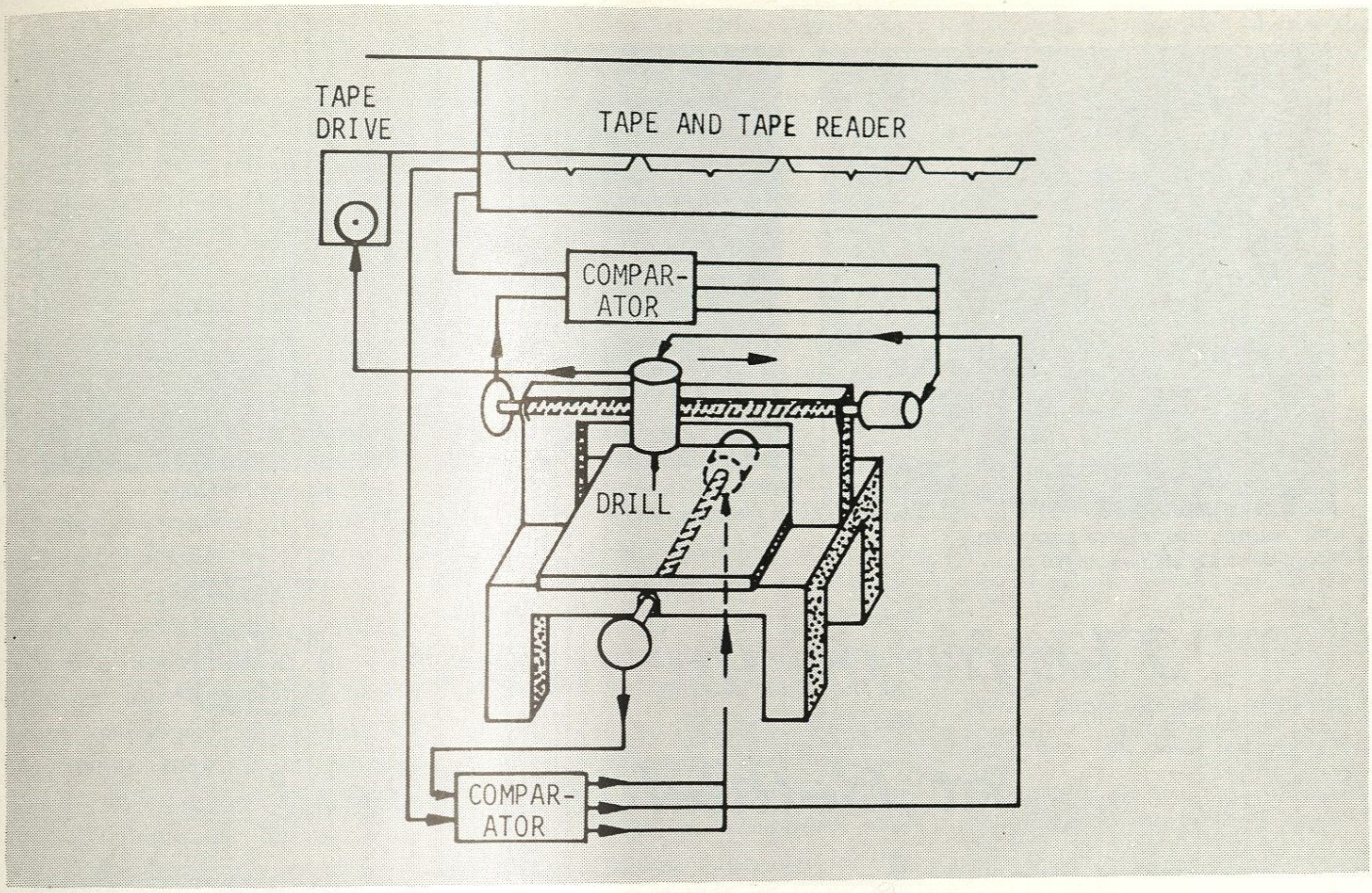

Figure 3 — Example of use of numerical control

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point on the surface can be given, an approximation using a series of straight-line segments can be given, a higher order approximation of segments can be used, or a family of curves might be adopted and their parameters specified. The first method is seldom used because it would require such a large amount of data to be fed into the machine, and the third method isn't used because of the complicated calculations involved. Most often a combination of straight line segments and a family of curves is used.

An example of the type of part that can be made on a contouring machine, along with the program for producing it is shown in Figure 2.

A numerical control system is made up of six major components:

1. The electronic control system
2. The machine tool
3. The drive unit
4. The feedback or servo-components
5. The electrically operated control equipment such as starters and relays
6. The manual controls

Tape instructions are read into the control system and after processing, electrical commands are sent to the drive units and to the control equipment. Commands sent to the drive units determine the lengths of movements and feed rates while those sent to the control equipment control spindle speeds, coolants, and tool changes. Servo-components are used to indicate the position of the tool so that a check can be made on the machine's performance.

The easiest way to understand the particular functions of these parts is to look at the schema in Figure 3.

This machine is a PTP drill press with numerical control used to regulate movement in two dimensions. The tape is first passed through a tape reader which converts the information on the tape into electronic signals that can be used by the machine. The reader is generally one of two types, either mechanical or photoelectric, although the slower mechanical type can be used in most PTP systems.

The electronic instructions are then distributed to the drive units and equipment controls by a central control board. This control board is made up of solid state printed circuits, which greatly improve the reliability and efficiency of the entire system over previously developed systems.

The servo-mechanism, which can be likened to the comparator in the schema, gives the machine a way to determine the position of the tool and also an indication as to the direction the tool must move to reach the desired position. Once the tool position is determined, the proper signal is sent to the drive mechanism. The

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TEACHING vs. RESEARCH

Some Thoughts On Student-Faculty Relations

DR. FRANK S. BARNES

An editorial by Kathy O'Donoghue in the January issue of the *Colorado Engineer* has stirred me to record some thoughts on the problems of teaching versus research and the student-to-staff relationship and to present them from the point of view of one who has been involved in making decisions with respect to this issue over a period of several years.

My first reaction with regard to this problem is the formulation of the problem, as teaching versus research is an oversimplification which is a convenient catchall to blame for all of the problems that occur in the complex area of student-faculty relations.

First of all, I find very little correlation between the student's opinion of a particular professor and the professor's research activity. There are professors in the Electrical Engineering Department who are highly regarded by students and who are not doing research and also who are doing research. There are also professors who rank at the bottom of the students' popularity lists who do research and who do not do research.

The second observation is that the student evaluation of a given professor changes from year to year. A professor who is highly regarded one year may be in the "student doghouse" one or two years later, and vice versa. In my short period of tenure as Department Chairman, I have seen at least five cases in which student opinion has changed very significantly over a period of less than three years and in both directions.

As a means of examining this question a little closer, let us ask what we mean by teaching and what one expects to accomplish by means of student-faculty interactions. First of all, from the student's point of view, he wants to leave a class at the end of the semester with a sense of accomplishment, that is, the mastery of some material or the feeling that he has learned something significant which will be of value to him later. However, much of what he hopes to attain from the classroom deals not with his present living, other than in the form of grades, but with his expectations of how it will bear upon his future professional activity. The expectations with regard to this future professional activity vary as widely in a given classroom as the number of students. Additionally, because of the rapidly changing technology and the limited student experience in the professional areas they expect to enter, the student's estimate of these needs is probably at best only approximately 50 percent accurate.

Now let's look at some of the problems from the faculty point of view. First of all, with today's job market, no faculty member takes a job at the University of Colorado unless he wants to be involved in teaching. Salaries are running 25 to 50 per cent higher in industry than they are in universities. I can vouch for this, as one of my students last summer received an offer in excess of the total salary of all but two or three members of our department. Additionally, it should be noted that the professor does not come to the university purely to deal with research, as there are places in industry which provide more equipment, better supporting facilities, and the opportunity to do research on a full-time basis. Again, men do not come to the university for a soft job, as our faculty workweek varies from 50 to 65 hours. I can only conclude from this that when they say they want to teach, they mean it. The question is what and how.

The joker in this situation is the very rapid pace at which technology is changing. Nearly every part of electrical engineering has changed radically in the last five years. Subjects such as tunnel diodes, lasers, and integrated circuits were virtually unknown five years ago, so that if a professor is to teach the things which he knew upon entering the university, he would surely be obsolete. Thus, a professor must continually acquire new knowledge, refine it, and present it in a form useful to students if he is to be effective.

This acquisition of new knowledge is closely related to research. It is time consuming, inefficient, and demanding; but without it, new material would not get into the curriculum in the way which is necessary if students are not to be obsolete before they graduate. Virtually every major change in our curriculum since 1960 has been initiated by faculty members who have been involved in research activity. However, this is not to say they have been most effectively carried out by these faculty members, as frequently these changes have been a two-stage process in which the refining of material was carried out by faculty members who had little or no involvement in the graduate program. It is extremely difficult, if not impossible, to recruit faculty members whom you expect to contribute to the development of the program in today's academic market who are not going to be involved in a graduate program. The quality of the faculty in all phases of activity and the easy way in which faculty can be acquired are directly proportional to the strength of the department's graduate program. In short, if you want a staff which will generate new undergraduate programs, you need a graduate program which is demanding new skills from the undergraduates, and faculty members who are aware of the demands.

In addition to this, research provides very real inputs to the undergraduates outside the lecture room. First, it provides financial support for about 10 students per semester. These students are having a chance to learn engineering skills while earning money, which I believe is more valuable than carrying groceries, working as a janitor, etc., and I would like to be able to expand our opportunities for undergraduate employment. Second, the research activities have financed equipment and facilities, such as part of the building, the hybrid computer, and the machine shop, which could not be justified for teaching purposes alone.

In the classroom, the faculty member, as I see it, is in the following situation. First of all ,he is no brighter than his best students; however, he has more experience in judging what is significant material than does the student. Thus, one of his important functions is the selection of appropriate material for study from the vast array of literature being published today. A bright student on his own, who has access to a good library, could learn all of the material he is likely to get in the classroom and a great deal more; that is, if he knew what to read and had sufficient self-motivation and drive to do it without prodding. A second function of the professor in the classroom is to help with the transfer of information. This may be done either by lecturing or by answering questions, although it is my feeling that any well-prepared lecture could be written down and passed out and students at the college level should be able to read it. The third function of the professor is to provide inspiration and drive by means of tests so that the student can acquire a working knowledge of the relevant material and set standards of performance. A fourth function, and possibly the most important one, is to provide the student with insight into how to go about discovering and organizing information for himself.

If the foregoing includes what might be a statement of goals of both the student and the professor, let us look at some of the processes which make the accomplishment of these objectives difficult. First of all, with respect to any given course, there is competition for both the professor's and the student's time. The student has competing courses, competing social interests, and possibly family or financial problems, plus an uncertainty as to how significant a particular course is to his overall objectives. Thus, he would like to get the maximum out of the course with the least amount of time and effort.

The professor's situation is somewhat similar. In addition to teaching any particular course, he is being asked to teach other subjects and to help with the administration of the university, either in devising new curricula, serving on various committees which decide matters such as the structure of new building, the layout of laboratories, the admission of students, disciplines, etc., or service to the community, industry, or the federal or local government. In addition to this, he is probably carrying on research which involves training graduate students whom he must keep financed and equipped. (It is to be noted that graduate students now represent more than 20 percent

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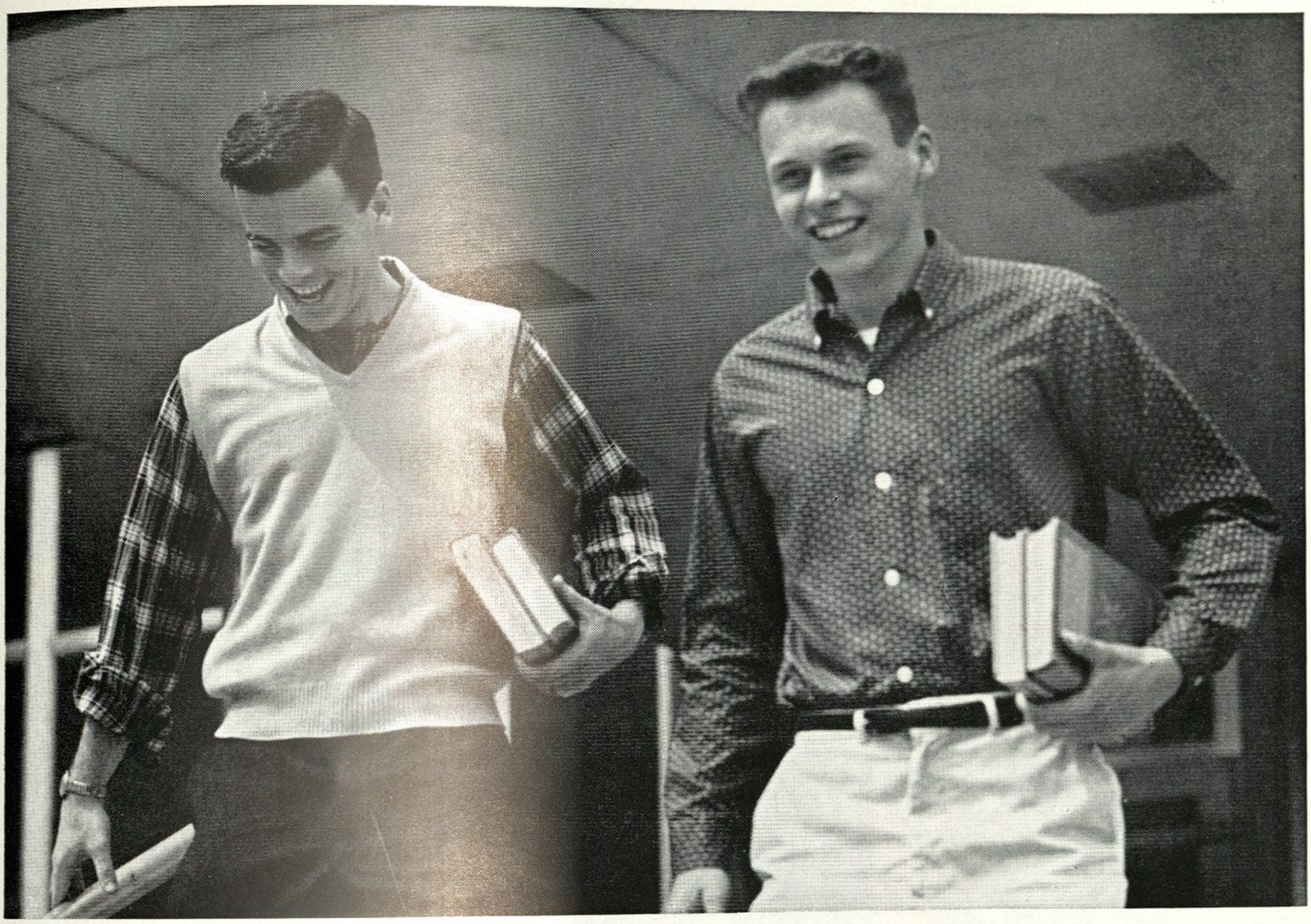

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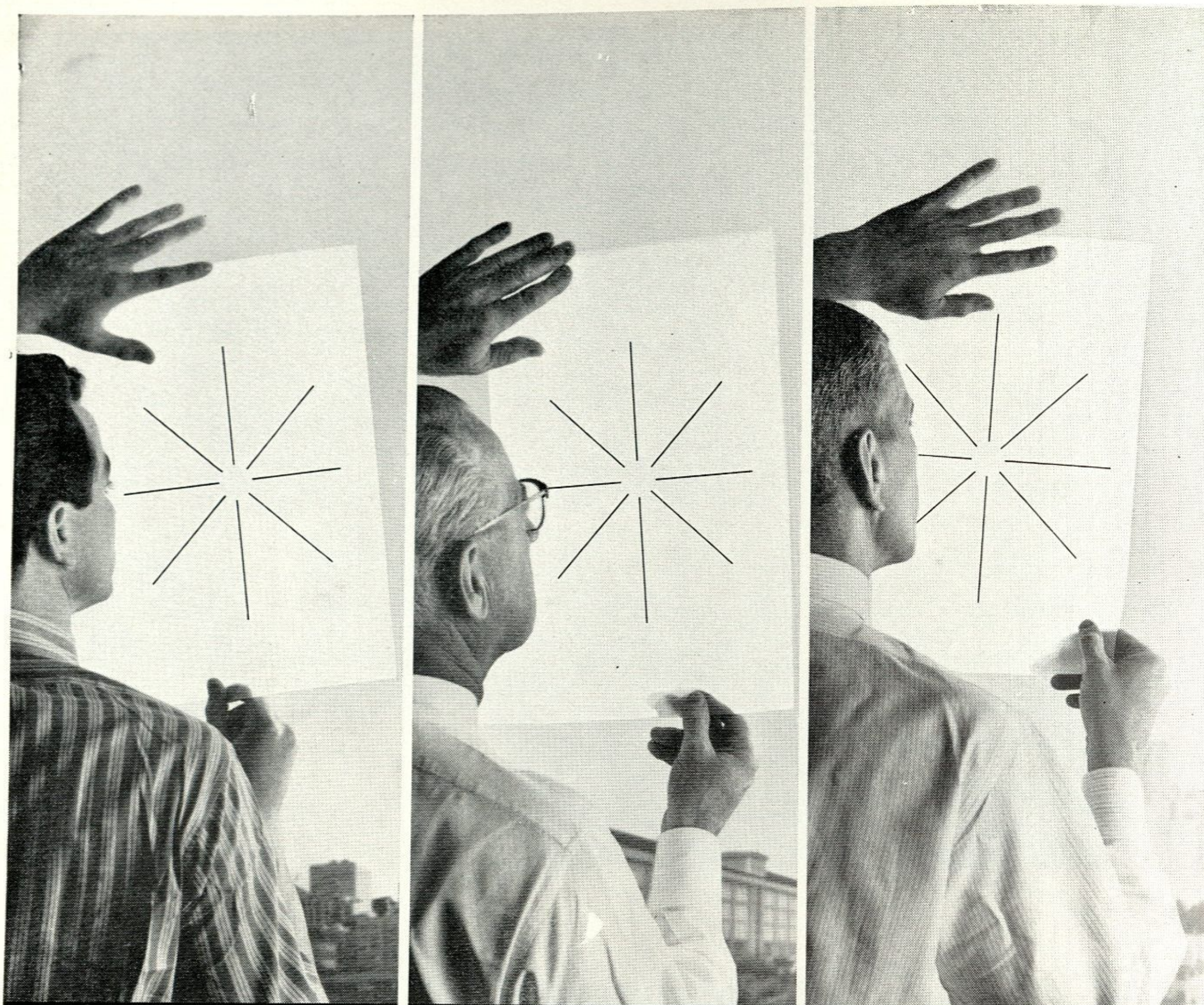


(Continued from page 38)

of our students, and they are trained by inefficient, time-consuming methods.)

Additionally, he finds that, independent of how the local university operates, there are two kinds of currency with regard to his job marketability: one, his local performance on campus in teaching and administrative service, and two, his research contributions to his profession. The latter is marketable across the entire country or world, whereas the former is of value only in one institution. These demands make the typical faculty workweek from 50 to 60 hours.

It is to be noted that the generation of new courses and new lectures is frequently responsible for a large fraction of his time. I find that it typically takes 10 hours to prepare a lecture in a subject for which a textbook does not exist. However, if the subject matter is well in hand and a good text is available, about an hour is required. It is also true that the lecture over the well-described material is better and more easily learned by the students. However, it is much more frequently obsolete and therefore of less value.

To conclude these observations, may I make the point that competition for time, both that of the student and that of the faculty member, is probably the most frequent source of ineffective information transfer in a given course. Both students and faculty are going to have to make compromises with respect to their expectations in these areas. The faculty member is going to have to make the compromise between the use of his time in acquiring additional and new material and its organization and presentation for students. The student is going to have to accept the compromise in the fraction of the professor's time which is spent in organizing and preparing material specifically for him with the up-to-dateness and quality of information which he gets. On the average the newer the information and the more active his professor is in acquiring it, the less time he is going to spend in its preparation for the individual student, and the less efficient will be the transfer of information to the student. The student is going to have to expect that, on the average, he will have some faculty members who spend too much time on research and not enough on classroom preparation, and some faculty members who have spent too little time acquiring new material and too much time presenting it. Additionally, students are going to have to take some responsibility in finding a way to utilize professors' talents as they find them, because very few professors are going to provide all of the characteristics they would like to see simultaneously. Faculty members are also going to have to take responsibility for balancing their time in competing activities to yield effective performance.

INDEX TO ADVERTISERS

CRYPTIC ARABIC

DAVID LAWRENCE

"Morning, boys. Having fun?"

Our Uncle Simon stepped into our lab with his usual cheerful greeting. His recent trip to Arabia must have agreed with him, for he was chipper as ever, and loaded with stories of the trip. My brother and I listened to him for hours that day, engrossed the whole time. One particularly interesting part of the conversation went like this:

"You ask about the Arab king I stayed with. Ah, his was a grand court, and as soon as I arrived I found puzzles and humor on every side. You see, the Arabs, being mathematically inclined, don't have jesters for their courts; they have *puzzlers.* The puzzlers spend most of their days entertaining the palace coterie with puzzles.

" 'Are they talented?' you want to know. Well, let me tell you about the selection of the court puzzler. When the present one dies or loses his charm, the post becomes available. Applicants from all the kingdom are required to undergo an initiation test. The quality of the applicants is raised, by the way, by the stipulation that all those failing the trial puzzles lose a finger. But those passing compete farther for the post, until the court can agree on a single one. It's a charming procedure, and it does produce the sort of people who can do the job.

"What is the test like? Ah, that's a secret, known only to the king and the applicants, who never tell. But I'll give you a sample puzzle, one which used to be in the test, until it leaked via a discouraged applicant who soon disappeared into the king's dungeon. The puzzle goes like this:

"The prospective puzzler is shown a bowl of twelve pearls and told that they are all exactly alike, save one. Eleven are cultured, balanced pearls. The twelfth is natural and worth a fortune. The problem is, if the eleven are all of equal weight and the twelfth is either lighter or heavier than the others, in *three* weighings with a balance, find the priceless pearl.

"The applicants were given ten minutes to think about the problem, then one minute to perform the three balances. If they required more time or failed to solve the problem, off went their fingers. If they succeeded, the job was possibly theirs. A fine test—ah, and why don't you boys try it for size. Go ahead, think about how you'd do it. You've got ten minutes.

(It's all yours. I lost one of my fingers on it, but my brother survived. DL)

"Yes, the puzzler was a competent man, and his ingenuity kept the king on his throne once. You see, every year the twelve nobles of the king's domain come together to present a tribute, a sack of fifty gold five-ounce pieces. As they arrive, they place their treasure in the king's vault, a strong, heavily-guarded room. They then retire to their guestrooms to rest for the ceremony the next day. The culmination of it all comes when the twelve of them pour their gold pieces into a large ceremonial bowl. Ah, it's an impressive sight.

"At any rate, all was peaceful on this particular night, the nobles were in their beds and the king was sleeping. It was sometime past midnight when there came a loud pounding on his door. In staggered the captain of his guard, pierced many times by swords and dying.

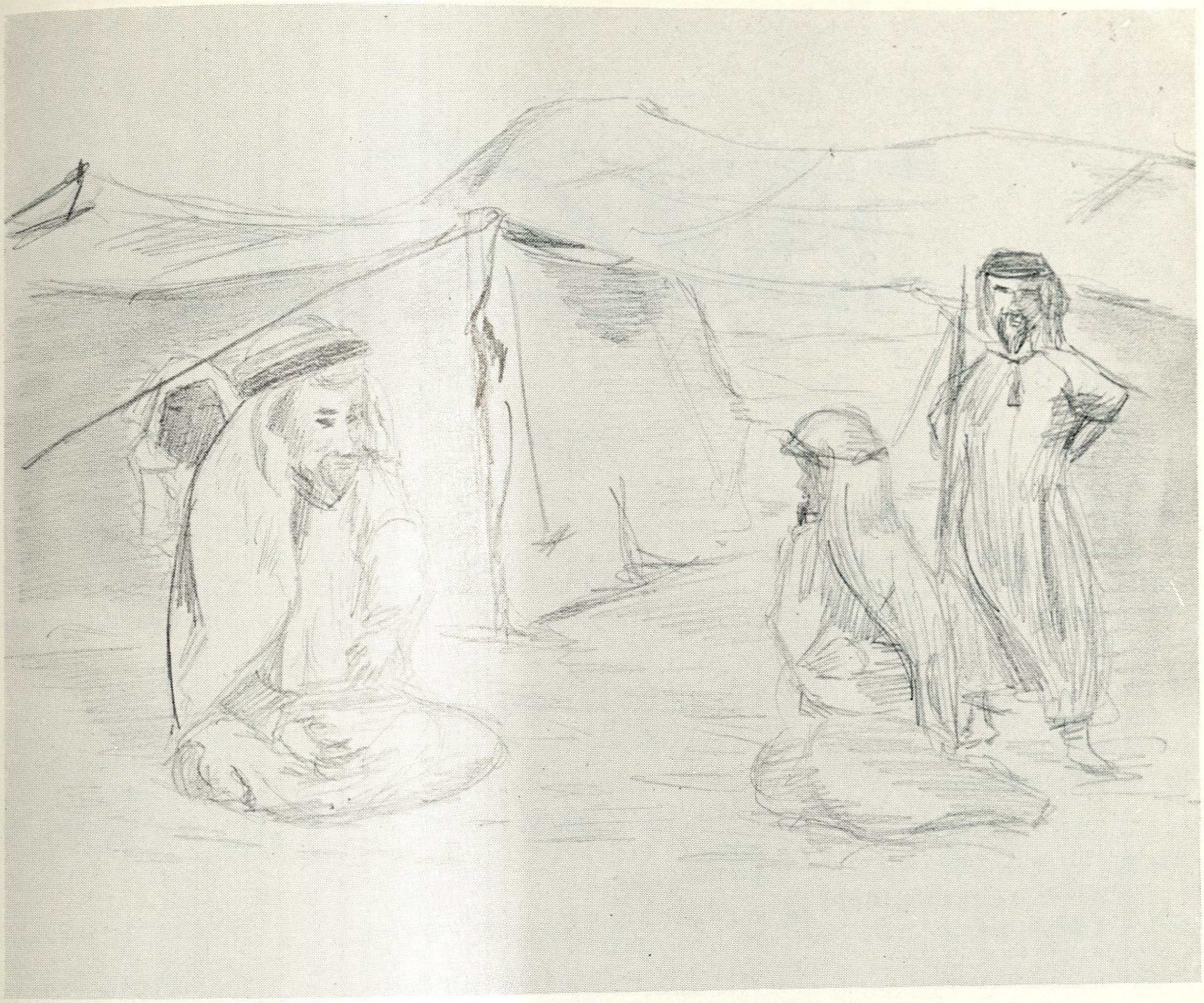
" 'Sire,' he gasped, 'there's a plot against you. One of your nobles is spreading distrust and rebellion. Even now, he has substituted alloyed gold pieces weighing an ounce less than the usual ones in your tribute sack. He plans to weaken your power by showing that you naively accept false goods for tribute, and anyone may cheat you without your knowing. Sire, it is only a step from that to rebellion, and . . .'

"The captain died before the king thought to ask the name of the treacherous noble. Thinking hard, the king walked about his room for an hour or so, then called for his puzzler. He explained the situation and asked for advice.

" 'You know, it seems to be our fate to depend on our puzzlers at times like these. Heiro II used Archimedes to find whether a crown given him was pure or alloyed. The puzzles you were required to pass to become a puzzler have their origin in actual situations. The pearl puzzle, for instance, originated in a situation much like this one. But now I don't know what can be done. Logic and math have changed a good deal since the days of Archimedes, but the nature of loyal subjects is still the same. Could a puzzler save a king, once again?'

" 'You need to know the identity of the traitor before the mixing ceremony tomorrow. Could you get them to agree to a weighing, sire?'

" 'There is precedent in custom.



The king may demand *one* weighing, if he suspects one of his nobles has cheated him. But I don't know which one of them is the traitor, and one weighing isn't enough to determine the false gold pieces. If I ask for more, I will destroy what faith in me they have now. If I don't accuse the traitor tomorrow, the others may likely go over to him. What am I to do?'

"The puzzler thought for a few minutes.

"'Are you allowed to place the coins on the scales, sire?'

"'Yes.'

"'And all weight the standard five ounces, except for the counterfeits?'

"'Yes.'

"'Then your troubles are over, sire. You will arrange things like this. . . .'

"And the traitorous noble was discovered, unity re-established, and the king's position strengthened. Oh, yes. The puzzle of the gold coins was added to the intiation tests soon after, also. Why don't you boys try it for fun?"

(Why indeed? And so it passes to you also. Good luck. DL)

ANSWERS TO CIRCUS CRYPTICUS

Uncle David laid down the paper he was reading. The story of the circus ringmaster who had given himself up for murdering our Aunt Martha (the trapeze artist Collette) after the police had called it an accident was on the front page.

"It is interesting to note that people picture things wrongly," said Uncle David. "Philosophers sometimes try to get to reality through mental pictures, holding that pictures are more real than words. But here was a case where peoples' pictures were wrong.

"Remember how the trapeze rope snapped when your aunt was poised in the air, at the *top* of a swing? Figure out the force on a pendulum rope at all points of its swing, and you'll find that the stress is greatest at the *bottom* of the swing, least at the top. In other words, if Collette's rope had been frayed, the probability that it would have broken after passing through a heavy stress, with less strain on it then, was very slight. Yet the picture people have of pendulums involves the most force on the rope at the top of a swing. Hence, the crowd, as well as the ringmaster, the man who cut the rope, saw the 'accident' occurring naturally. But the picture didn't look right to someone who had basic physics, and I deduced that the improbable point of breakage indicated murder.

(About the lion—Well, Uncle Percy is due back from his adventures in South America next month and the May issue of the *Engineer* should have the answer. DL.)

He: "Why is it the most important men on campus have the best looking-girls?"

She: "Why, you conceited thing!"

Frank: "My wife worships me."

Charles: "Oh, really?"

Frank: "Yeah, she places burnt offerings before me every night."

"I don't like Bill," confided a coed to her roommate. "He knows too many dirty songs.

"Does he sing them to you?"

"Well, no—but he whistles them."

Conscience—The thing that hurts when everything else feels so good.

"Frequent water drinking," said the specialist, "prevents you from becoming stiff at the joints."

"Yes," replied Harold, "but most joints don't serve water."

The trouble with lying around and doing nothing is that you can't stop to rest.

The mama broom and the papa broom had a little whisk broom, but they couldn't understand it since they had never swept together.

Don't start any vast projects with half-vast ideas.

The boss was chasing his secretary as usual.

"Why don't we go up to my apartment tonight?" he asked.

"I am very didactic and pithy in my refusal of your very derrogatory vituperative and vitulic proposition."

"I don't get it," her boss replied.

"That's right."

The teacher was telling her junior high charges the merits of owning a yearbook and having one's picture in it.

"Just think, thirty years from now, you can look at it and say, 'There's Bobby Maxwell—he's a pilot now. And there is Sandy Williams. She's a nurse. And there's . . .' "

"And there's teacher. She's dead."

"I'm glad I have a sense of humor. Every time I see something funny, I laugh and laugh."

"Boy, you must have a helluva time shaving."

The little tyke took his ten cents allowance to the candy store to buy some little chocolate babies.

"And I want all boy babies," he told the clerk.

"Why is that?"

"More chocolate."

Frosh Engineer: "I hate this place."

Sophomore: "It could be worse."

Junior: "It's rough, but it'll be well worth it."

Senior: "I hate this place."

Tourist: "I'm starved. What's for dinner?"

Waitress: "Today's special is broiled beef tongue. Would you like some?"

Tourist: "I'm not going to eat anything that came out of a dirty cow's mouth. Just give me a couple of eggs sunny-side up."

—John Brooks

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