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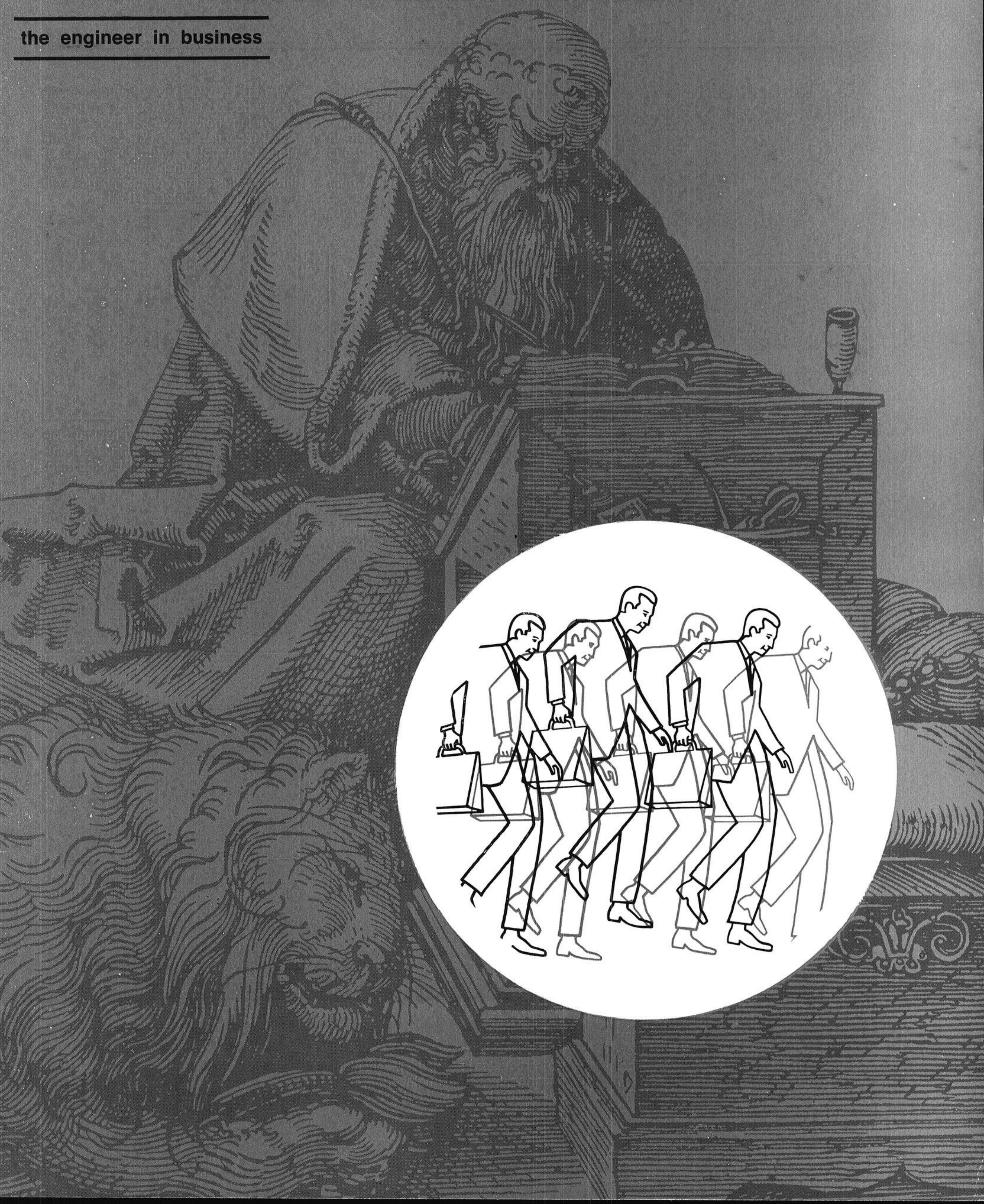
wisconsin engineer

the engineer in business



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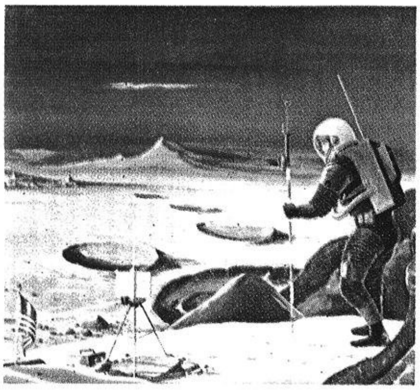

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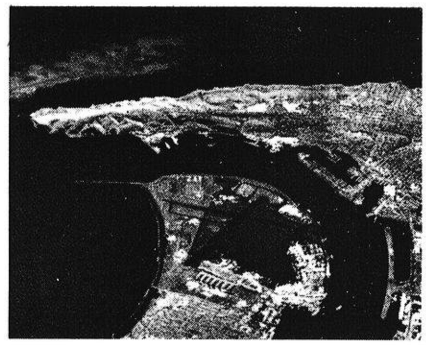

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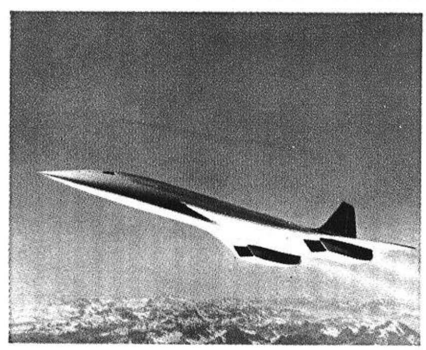

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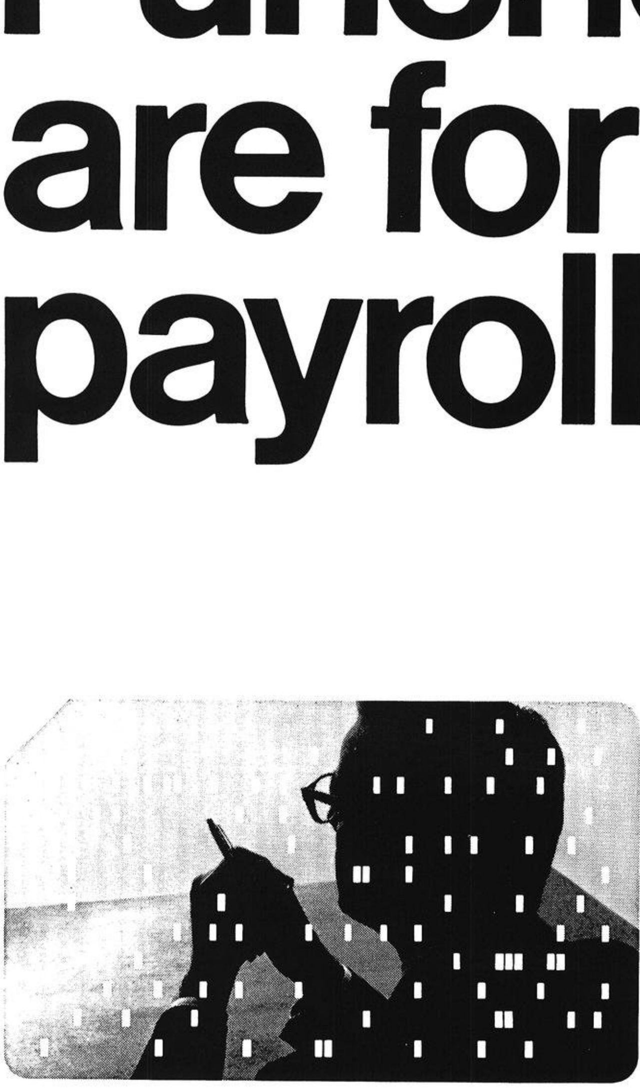

FEATURES:

REAPPEARING NONENTITIES:

wisconsin engineer

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EDITORIAL

Oh, Diogenes

Diogenes was looking for an honest man — and I'm looking for an honest appraisal of the T.A. system. If the department chairmen are going to use teaching assistants more and more extensively, then it is time that they considered the quality of the education the undergraduates are getting. Even junior and senior level courses are being taught by T.A.'s now, but not all these teaching assistants are teachers. It is too important, by the time we reach the junior and senior level, to risk a bad teacher!

What are the common faults of a teaching assistant? Basically, it is not remembering what it was like when he was first learning the material he is trying to teach. He does not have the time, or does not take the time to teach effectively. Working problems on the board, or re-reading the book to the class is not enough for most students. Students, to learn, need two things: material that is challenging, but thoroughly explained, and a teacher who is so familiar with his subject that they respect him and as a result his subject. No one respects a teacher who — every time a question comes up that's not in the book — says, "I'll have to look it up," or "Don't worry about that. It's not relevant and it won't be on the final."

What's the answer? Possibly a short, mandatory training course, along with a much more careful screening of a graduate's qualifications as a teacher and not just as a graduate student. He should be closely and carefully supervised throughout his teaching — and his ability to communicate his ideas judged as a part of his degree. Most of all, before he could teach a junior or senior course, he must have understudied for at least a semester, sitting in a class as a professor's assistant.

Certainly, if a graduate were willing to do all this, and the department willing to provide this help, we could have some quality instruction, and turn out more and more top students.

Mary E. Ingeman
editor

Can there be this kind of excitement in engineering?

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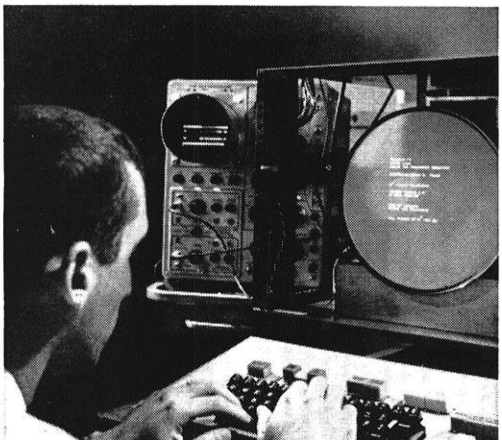

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WILL POSITION SPOIL THE ENGINEER?

Predictions of a coming management shortage in the electronics industry are wrong. The "management gap" exists today! The only uncertainty about the future is how much worse it will get before it gets better — if it gets better.

I know of no electronics company that isn't concerned about the shortage of skilled managerial personnel. And when you look at the electronics future — it s continuing and accelerating growth, the constant change, the increasing complexity — by the 1970s there will be a management shortage unparalled in any sector of the economy.

It is a well-known fact that there has been an acute shortage of engineers and scientists. But I believe that too little emphasis has been placed on the critical shortage of management talent. If electronics is to continue its present growth rate, new sources of management must be found. Where are those people to come from?

As our industry grows we will continue to fill management jobs with people trained in one or more of the functional disciplines of our business — be it manufacturing, engineering, personnel, marketing or finance. We will pick them, however, not because of their professional accomplishments but for their management skills.

This is what we have been doing all along, but it hasn't been enough. We can't wait for managers to "come to us" and to naturally rise to the surface. We must find large, virtually untapped sources and concentrate on developing the managers of tomorrow. One such source that I believe has been sorely neglected is the technical staff.

Built-In Management Pool

There is a made-to-order "pool" of potential managers in the technical staff of most companies. When all is said and done, who should be better equipped for managing a technically based company than the engineer? He already has "one leg up". His engineering. disciplines are an excellent foundation for learning to solve business problems. And his entire training should orient him to systematic management approaches.

This is not to say that every technician or engineer will make a competent business manager. Many just aren't temperamentally equipped to manage. Others want no part of it. And let's face it, some shouldn't be managers. But I don't subscribe to the tired cliche that "engineers make lousy managers" or "make an engineer into a manager and you lose a good engineer and gain a poor manager".

Of course, not all engineers make good managers. Neither do accountants or advertising men or business school grads for that matter. But I predict that, by the very nature of our critical future needs, more and more engineers will have to "cross over" to management if we are to continue our industry's planned growth.

What do I mean by "manager" in the context of this article? I do not mean a project engineer or an engineer in charge of a technical department. I mean the management of a unit where there is *profit responsibility*, where in effect a "business" is managed. It makes little difference whether it is as small as a product line or as large as a multi-division company. But it is impossible and unnecessary to write an all-inclusive job description for a manager if for no other reason than the "human" aspects of the job require too many descriptive adjectives. And adjectives are subject to too many human descriptions. To further confuse the problem, two equally successful managers, more often than not, have varied differences in personality, background and strengths and weaknesses.

However, there are a number of common ingredients that can be found in most successful managers.

- They are true leaders with broad curiosities and interests.
- They are capable of making decisions.
- They have an ability to measure risks and a willingness to take them.
- They can see beyond today and can plan for the future.
- They have a "total" concept of their business and a working knowledge of all of its major components.
- They know that it takes more than one functional strongpoint to make a lasting business.
- They are constantly striving for balanced and coordinated strengths in all phases of their company or unit — manufacturing, finance, engineering and marketing. And they have sufficient understanding of all of these functions to accurately measure performance.

.... And last but most important —

- They have a never-ending concern and involvement with people. They can choose the right people and inspire them. They can lead but they can also delegate. They know when to dig in and when to stay out. They are flexible. They can fit people to jobs and fit jobs to people. They can organize a team and they can get it to work. And they have a deep and fundamental understanding that their success or failure is ultimately hinged on their ability to work with and through people — as a team.

Making the "Cross Over"?

Just as there are no simple ways of defining a manager, there is no simple way of describing how to become one. It can be clearly seen, however, that the engineer who aspires to manage must do more than merely "keep up" with developments in his technical field. Much more. He must broaden his inquisitiveness and knowledge to include all phases of business. He may have to read as much as ever in technical publications, but he's going to have to read a lot of other things as well.

At every opportunity he should not only notice but try to *understand* the concepts and rationale that are inherent in other functions of the company. It is not enough to know how to fill out an accounting form or cost estimate. He should learn why it's important and how it contributes to the company's overall operations.

Additional formal education would, of course, be helpful. But every engineer doesn't have the opportunity of attending a graduate school of business. There are other avenues available to him, including night schools, correspondence courses and countless text books and periodicals. Associating with and "picking the brains" of professionals in other functional departments can also contribute heavily.

The most vital consideration to the would-be manager is the company itself. The more enlightened companies recognize the need for management development and provide the necessary environment and support. Most of today's managers were developed "on the job" and it will remain true for most of tomorrow's managers as well. The best single suggestion is to select a company where you will be surrounded by good managers. Ignore the false prophets who advise joining a company with poor management so you will easily be able to "shine". Working under or with a good manager is the best possible way to prepare to "cross over".

In summary, the management gap is here today. It will continue to get worse and will become highly critical in the early 1970s. Many non-engineers will help fill the gap and will of course play a vital role. However, many of today's engineers should also be tomorrow's managers, if they are willing to start working at it now. It will take lots of dedication, self-discipline and sacrifice. It's not easy and it's no project for the "ninety-day-wonder".

On the positive side, the opportunities are there and the rewards — both personal and financial — can, in amazingly short order, compensate for a lot of hardship.

J. S. Webb

executive vice president — TRW

—reprinted from March, 1967,
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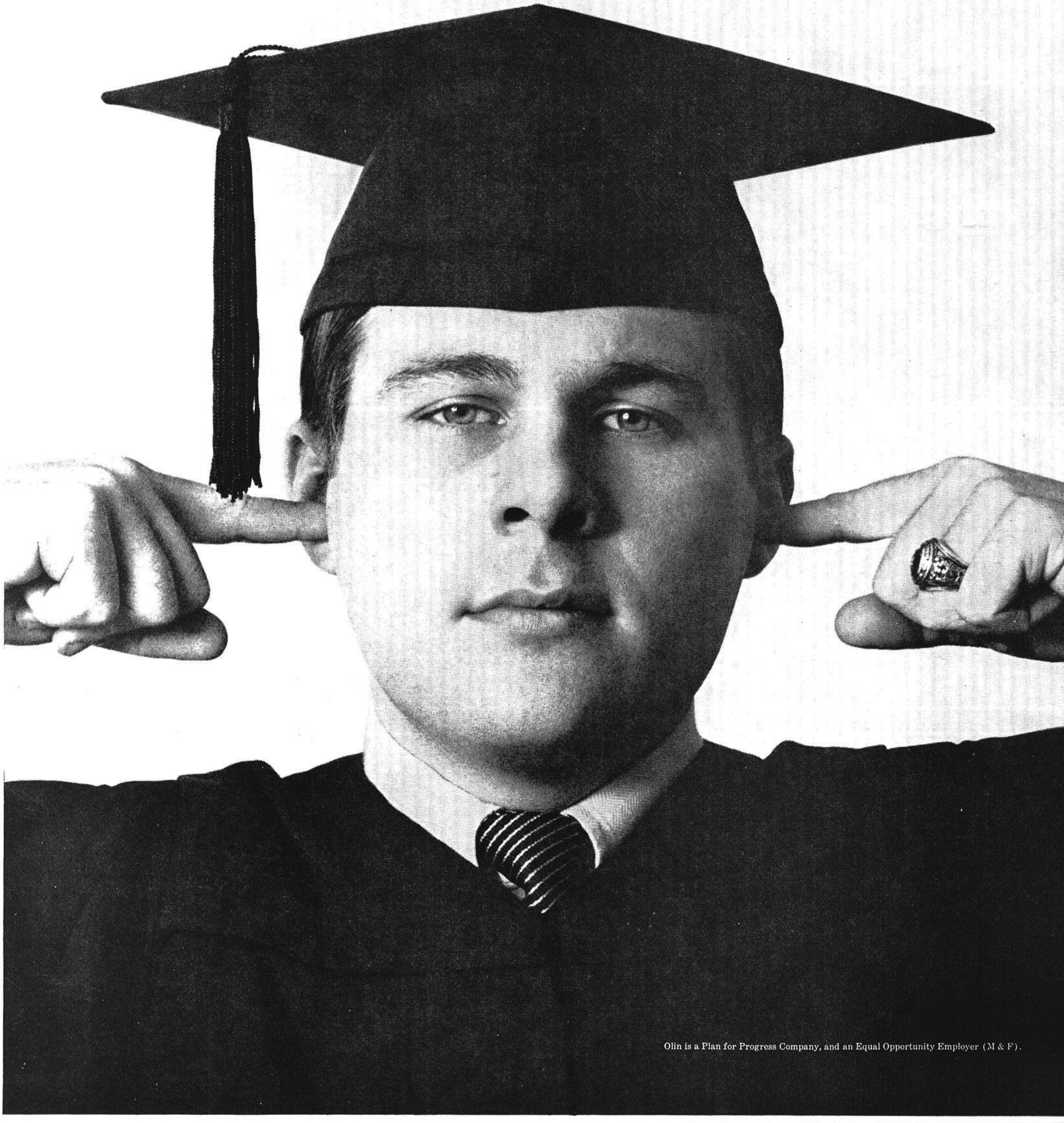

UNIONISM: PAST AND PRESENT

by Elmer Beale

Soon after the American Revolution, unions were founded. Contrary to popular belief, these unions were founded in the skilled trades such as the shoemakers trade, instead of in manual industrial groups. Until 1820, unionism was confined largely within these skilled local groups in the principal industrial centers along the Atltantic coast.

The characteristics of American trade unionism can be explained largely by several conditions peculiar to the history of the country. These characteristics are: limited occupational and industrial penetration; instability of membership; craft and racial exclusiveness, and the absence of a permanent political labor front.

The first of these conditions was the unlimited possibilities of economic and social expansion. Internal migration and immigration resulted in diversified communities along with only limited class structure. Another factor of importance was the absence of a feudalistic background and a more complete and earlier realization of the democratic revolution. The third factor is the lack of homogeneity in the working class, especially prevalent after the Civil War. The next condition was the development in the last quarter of the nineteenth century of industries which looked largely to immigrants without trade union background for their main source of unskilled labor. Finally, there has been the unprecedented, rapid technological change in industry.

FACTORS IN UNION DEVELOPMENT

These factors completely formed the pattern of trade unionism up to the 1920's. It was the change of industrial policy on the part of the federal government which brought all trade unions into line and for the first time produced what can properly be called a trade union movement. Another factor was the growth and increasing power and influence of the American Federation of Labor. These conditions resulted in another transformation of American labor during the 1930's.

Although there were many facets of the transformation, three are particularly noteworthy because of their long-run implications. The first was the shift from a commodity to a welfare concept of employment. Firms began to adopt welfare and benefit programs for their employees. The second was the widespread intervention of government in the employment relationship, with emphasis on humanitarian considerations and expansion of purchasing power. Finally, the third was the spread of industrial unionism, with accompanying innovations in organizing methods, leadership, and political policies.

The government's role in union development can be broken down into three periods. The first was brought on by the Norris-LaGuardia Act of 1932. It was the first sign of the shift of sentiment in a pro-union direction. This period saw the government actively help the development of unions. The National Industry Recovery Act of 1933 was also important because it provided workers "the right to organize and bargain collectively through representatives of their own choosing.' The Wagner Act of 1935, The Fair Labor Standards Act of 1938, and the Social Security Act of 1935 also were pro-union. Needless to say, this period showed a tremendous rise in union membership and influence.

Following World War II, the country experienced an enormous number of long, violent and costly strikes. These conditions resulted in public pressure to curb the unions. Therefore the second period was one of restriction of Unions. The Taft-Hartley Act of 1947 was passed with this aim in mind — to balance the power between industry and the unions.

Finally, the third period was based on a crack-down on unions to eliminate corruption in the unions. The Special Senate (McClellan) Committee in 1957 disclosed extreme internal corruption and undemocratic practices in many unions. The result was the enactment of a union reform law called the Landrum - Griffin Act in 1959. This Act set up certain restrictions and responsibilities which the unions must uphold for both its members and the public.

Broadly speaking, then, the 180 years of union history in America divide themselves into three periods: (1) a century of fluctuation before a stable organizational pattern was achieved (up to about 1890); (2) some 45 years in which craft unionsm philosophy predominated; and (3) the era of industrial unionism under regulating legislation (1935-65).

DEVELOPMENT OF THE STRUCTURE OF UNIONS

Unions are based on four major types of structure. The first is organized around a craft or group of crafts. Here the productive process and the common skills establish similarity of interests. Secondly, unions may organize around a product or series of products. In this case the common interest lies in the product itself and from employment by the same enterprise or by enterprises related by the market competition.

The third structure is based on the influence of a dynamic leader or the power which flows from a strategic location in society. This may serve as a basis for a general union which follows neither the logic of craft nor product organization. Fourth, a union may concentrate attention on wage rates, hours of work and working conditions in a particular place of employment. Such a union is unrelated by craft skill, by product, or by union power to other groups of workers. Company unions have traditionally been of this type.

In addition to distinct structural types and varieties of unionism, there also seem to be four functional types of unions. The first and perhaps the most clearly recognizable functional type may be termed business unionism. It appears largely in the programs of local and national craft and compound craft organizations. It is essentially trade - conscious, rather than class - conscious. It expresses the viewpoints and interests of the workers in a craft or industry rather than those of the working class as a whole. It aims chiefly at more advantages, here and now, for its members.

The second union functional type seems best designated by the terms, friendly or uplift unionism. It is characteristically idealistic in viewpoint. It aspires chiefly to elevate the moral, intellectual, and social life of the worker, to improve the conditions under which he works, to raise his material standards of living and give him a sense of personal worth and dignity.

A third distinct functional type may be called revolutionary unionism. It is extremely radical both in viewpoint and in action. It is also distinctly class - conscious rather than trade - conscious. It seeks to unite all wage workers into one homogeneous fighting organization and looks at all existing methods of union - management relations as means of further exploitation of the workers.

Finally, the fourth distinguishing type is predatory unionism. It can not be set apart on the basis of ultimate social ideals or theory. This type appears to aim solely at immediate ends and its methods are wholly pragmatic. Its distinguishing characteristic is the ruthless pursuit of the thing at hand by whatever means seem most appropriate at the time.

TYPES OF UNIONS

The three levels of Union organizations are : (1) the local organization; (2) the national organization, and (3) the federated organizations. The local unions are those set up usually in a specific geographic location. They are responsible for local bargaining and contract settlements. Locals with similar structure and function may be united into an international union. The International (or National) organization decides at what level and to what extent the negotiations will be held. They are interested in lobbying and in industry - wide bargaining. The third level is the confederation of unions where a number of international unions of similar or different types will unite to combine their influence and power. The confederation's main responsibility is lobbying for favorable legislation. It is also the main financial power in assisting further organization.

The main federation in the United States is the A.F.L.-C.I.O. which has 13 of the 18 million union members. The American Federation of Labor (AFL) and the Committee for Industrial Organization (CIO) merged again in 1956 after the CIO had been ejected from the AFL in 1936.

Originally, the AFL was set up on a craft unionism basis, and did not want to organize the industrial workers. A group of member unions headed by John L. Lewis of the United Mine Workers set up a committee within the AFL called the Committee for Industrial Organization (CIO). Its purpose was "to encourage and promote organization of the workers in the mass production and unorganized industries," and to affiliate them with the AFL. Clashes began to occur between the AFL and the Committee and finally on August 4, 1936, the AFL ejected the member unions of the CIO.

This break, however, probably worked out for the better because rivalry between the AFL and CIO helped the development of unions by making them both strive for effective organization.

The major functions of the AFL-CIO are to promote the interests of workers and unions before the legislative, judicial, and administrative branches of government; to expand union organization; to provide research, legal and other technical assistance to their members; to represent and promote the cause of labor before the general public; and to serve as spokesman for their unions on international affairs, especially international labor movements.

PROCESSES & PROCEDURES OF COLLECTIVE BARGAINING TODAY

The Unions' entire strength is based on collective bargaining. It is their tool to equalize the power of management and to reach their goals.

Collective bargaining is not a discrete event or one bargain. Instead, it is a continuing, legal relationship. It consists of a series of contract negotiations and of day - to - day negotiations under the grievance procedure. The negotiations are conducted by representatives of the union and management, backed up by their collective powers. Collective bargaining is also a process of adjustment or mutual accommodation between the union and management, in which acceptance is an important ingredient. Although unions and management have different viewpoints and goals, nevertheless they have a mutual interest in arriving at a workable compromise in order to develop a satisfactory agreement. Therefore, collective bargaining is a mixture of conflict and cooperation, of rivalry and mutuality and of problem-accentuation and problem-solving.

Management's basic approach to collective bargaining is founded on three elements. The first is the goals of the firm concerning its survival and growth, market position and profits. Secondly, is its rights, such as freedom, to take necessary action to cut costs and to maintain efficient operations. Finally, management wants a satisfactory workforce, which means a productive body of employees.

Like management, union leaders have certain basic beliefs concerning collective bargaining. First, they have a strong faith in collective bargaining as a method of decision-making. Their second belief is that the union and collective bargaining are necessary in order to protect and promote the interests of the membership. Third, they have a desire to enhance the security and strength of the union as a collective bargaining institution.

There are three stages in the development of successful collective bargaining. The first is the signing of a contract by a company giving a union the right to bargain for its members only. In the second stage, individual companies concede a stable position to the union and cooperate with it in the adjustment of personal grievances. In the third stage, collective bargaining becomes a cooperative relationship directed toward increasing the productive efficiency of the industry.

NEGOTIATIONS

Since the conditions governing each union - management negotiation are different, it is difficult to list universally applicable rules for collective bargaining. For a negotiator the most important pre-requisite is a detailed study and a thorough understanding of the issued involved. Also the negotiator must have clear in his mind the material which he wants to present, and in what order. All the points that he makes should be related to the negotiators' needs, wants and interests.

During actual negotiations the negotiators should always try to be open-minded. They should be ready and willing to listen to all arguments and facts presented by the other parties, and the merits of a particular point should be carefully weighed to recognize the advantages and disadvantages to be gained by its adoption and incorporation in the final agreement. Open-mindedness, a willingness to examine the facts, and an earnest desire to change points of view that may be proved incorrect are the conditions for successful negotiations.

A typical collective bargaining session would be something like the following:

(1) The union makes some extreme proposals.

(2) The company replies with proposals. It usually does not suggest any changes from the contract.

(3) They discuss the demands.

(4) The company makes an offer.

(5) They discuss again (usually neither party yield).

(6) The union says that the company won't budge and their members vote for a strike.

(7) There is last minute bargaining.

(8) A mediator is asked in.

(9) There is a settlement.

(10) The union members ratify the contract.

ALTERNATIVES FOR FORCE

Meditation

Since joint negotiations are not always successful, a third party known as a mediator may be very helpful in bringing the two sides together again for further conferences. The mediator's primary responsibility is to keep the parties together at the conference table. As long as negotiations continue there is a chance for agreement. The mediator is simply a third party who tries to get the other two parties together. He can only make suggestions and does not have any power to make the parties settle. Sometimes, by acting as a confidential intermediary, the mediator may learn what each side will concede and may thus find common ground for an agreement. Often, because of his position he is able to get concessions which neither would grant to the other in his absence. Many times his most important duty is to find a solution which will permit the contestants to accept a compromise and still retain their dignity.

A Federal Mediation and Conciliation Service has been established by the Federal government as an independent agency. The Service has a staff of mediators distributed throughout the country. Under the Taft-Hartley Act, labor and management are required to notify one another of a desire to modify a collective agreement 60 days prior to its termination. With 30 days after that, if there is no agreement, they must notify the Federal Mediation Service. If mediation is then necessary, the Mediation Service will send a mediator to sit in with the negotiations.

Mediation then may break down into one of three stages. One is settlement, the second is arbitration and the third is strike. Most of the time the strike leads to arbitration.

Arbitration

Arbitration is generally not used because both unions and management are afraid of its consequences. When using arbitration, there has to be a settlement. If the two parties cannot agree on a compromise, then the arbitrator decides on a fair settlement and both management and the union have to accept it whether they agree with it or not. In this light, the work of the arbitrator and the process of arbitration is entirely different from that of the mediator. The main point is that arbitration is


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a judicial process. The arbitrator sits as a judge, called upon to determine the legal rights and economic interests of the parties, based on the facts presented.

Arbitration may either be voluntary or compulsory depending on the situation.

USE OF FORCE

If a settlement cannot be made and neither party will concede, the Unions will resort to force. The union's techniques of force are: (1) strike, (2) boycott, and (3) on-the-job activity.

Strike

There are two major types of strikes, the spontaneous and the planned. Under negotiation conditions, strikes will almost always be of the planned type. Spontaneous or "wildcat" strikes usually occur because of some unusual incident during normal on-the-job activity. The potential strength of a strike is that it means that the industry will be shut down and therefore unproductive. Management must then weigh the losses occurring because of the strike and the losses which would occur if it accepted the terms of the unions. The unions have an important decision to make also when considering to strike or not, because if they do strike, it will mean loss of wages to members. Therefore, strikes are costly to both sides, and supply and demand will influence the effectiveness of the strike.

Basically then, a strike puts economic pressure on both sides to reach a settlement and to search for a mutually acceptable compromise. As a strike deadline approaches, the pressures for compromise increase. The range of acceptable compromises may expand as the strike deadline nears, since both sides will want to avoid strike losses. Work stoppages are generally unpredictable in length, and costly. Therefore, the parties may become less stringent in their demands and limits for compromise when the alternative is clearly a strike whose course is very uncertain.

A long strike may make the parties a little more lax, but many times it serves to restrict the latitude of union leadership and management. For example, with reduced profits or a sizable loss to recover, management may not be able to extend liberal industrial relation policies. Also, union leaders may feel less secure and be more governed by membership opinion. Many times the hardships of a strike result in the criticism of the union leadership and the development of rival leaders.

Although both unions and management usually support their positions in strikes by economic arguments, their main reason in calling or accepting a strike may lie elsewhere. Unions may strike to teach management to respect the union or to solidify or sober their membership. The losses incurred by the members because of the strike may be considered as an investment in the union itself and an investment in better day-to-day treatment of the workers. Labor organizations are always seeking their security and growth as institutions.

On the other side, management may sacrifice profits in order to keep their principles or to teach the union a lesson. This lesson may be that the company wants to make it clear to the union that it cannot expect to force management to accept unreasonable demands by strike harassment.

Boycott

Another form of force which may be used is the boycott. A boycott is a concerted effort to withdraw and to induce others to withdraw from economic or social relations with offending groups or individuals. Boycotts were used mostly during the period from 1880 to 1908. It was a very effective weapon used by the Knights of Labor. However, now most of the boycotting techniques are termed illegal. One of these illegal tactics was the "black-balling" of union workers used by management. Secondary boycotts which were used by sympathizing unions also became illegal with the passage of the Taft-Hartley Act of 1947.

Many people have the impression that after a contract has been signed no other gains can be won until contract negotiation time comes around again. This is not true. To make the contract effective on the job, and to win improved working conditions, is a year-round job for stewards and members.

LABOR, MANAGEMENT AND THE PUBLIC

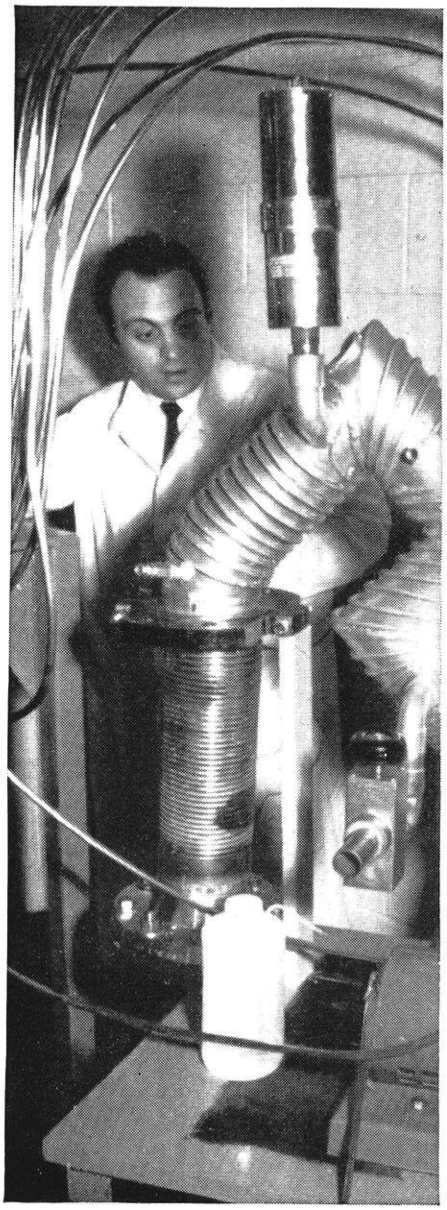
E. Wight Bakke and Clark Kerr sum up the situation between unions and management and the public in the following paragraph.

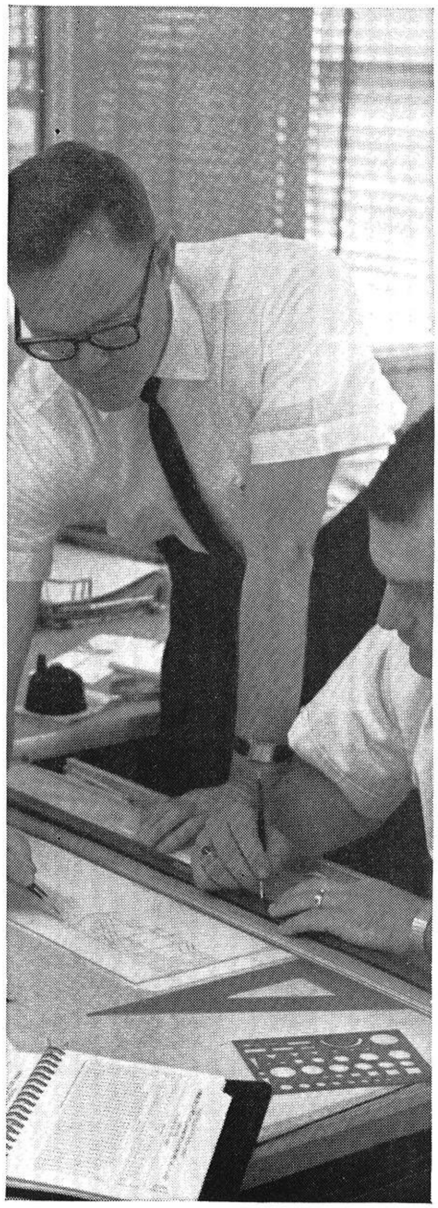
"Whenever enough people get hurt by the actions of other people, the protection of the public interest becomes a popular issue. Whenever individuals or groups get enough power so that their actions can create havoc or happiness in the lives of many people, the protection of the public interest becomes a critical issue. Both of those conditions exist today in labor and management relations, and, true to form, all of us, including management and labor, are getting deeply concerned about the public interest."

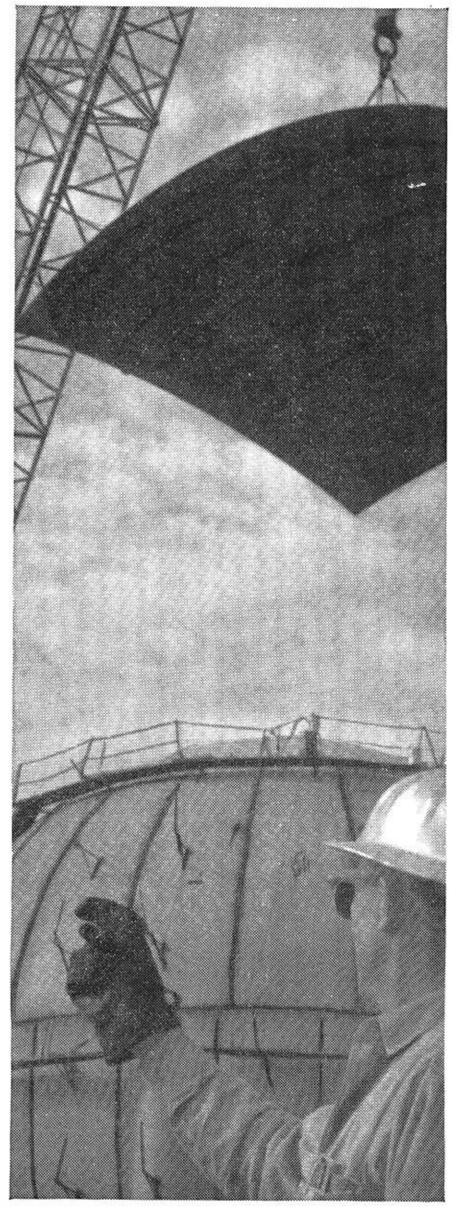
The problem involved is that "public interest" means different things to different people. People tend to identify public interest with what is best for them. This is one obstacle which hinders labor leaders and management in agreeing on the nature and importance of the public interest and having it govern their actions.

The second obstacle is that there is a battle raging over the shift of power and prestige in industry and in the community between the leaders of business and industry and the leaders of labor. Connected with the second obstacle is a third. It is that these two economic groups are engaged in a struggle for a new balance of power. Labor wants each issue solved so that the balance of power swings in its favor. Management, on the other hand, is trying to hold on to what it has.

When these obstacles are overcome, the union-management relations will be compatible with the public interest and everyone, including both management and unions, will profit from the results.







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Operations Research

by Edward David La Course

"Operations research." Commonly abbreviated as "O.R.," this field has an almost exotic-sounding name. It conjures up visions of bald, bespectacled theorists working on the top floor of a giant building, of trench-coated military men poring over war plans, or of a group of intellectual young businessmen behind the scenes who decide what General Electric is going to do next year.

The purpose of this report is to alleviate the vagueness about exactly what operations research is. It will be shown that O.R. is actually the practical application of scientific principles and methods to optimize an entire system. This system may be a large corporation, a small business, a military force, a hospital, or any other complex physical entity.

Since there are many entire books dealing with operations research either in part or as a whole, this report is necessarily rather limited in scope. It will concentrate on the basic concepts of O.R., and give only a very few examples of the models which have been developed for various systems.

The first part of this report will cover the nature of operations research, including a definition and some background and history. The O.R. method is then gone over in detail, and applications of O.R. to industry are noted. A section of sample models is included to illustrate the usefulness and techniques of O.R. Finally, a glance is taken at the future outlook of the field of operations research.

Definition

Operations research is the application of scientific methods, techniques, and tools to problems involving the operations of systems so as to provide those in control of the operations with optimum solutions to the problems. There are several key words in this definition. "Application" implies that operations research is a science which is meant to be useful; elegant mathematical techniques are of no value if they cannot be applied. "Scientific" denotes that O.R. uses quantitative methods to achieve its results, which is far superior to qualitative judgments. "Systems" refers to the fact that O.R. strives to obtain solutions which will improve the total system. It does no good, for example, to cut costs in a grocery store by hiring only one cashier if customers become so dissatisfied with the service that they stop coming altogether. And finally, "optimization" suggests that the solutions which O.R. presents are the best possible for the overall system, rather than only a "better" solution.

Background and History

Operations research is considered a branch of industrial engineering. Industrial Engineering (I.E.) is the application of the scientific method to any management problem. Specific instances of I.E. techniques date back to before the time of Christ. In Chapter 18 of the Book of Exodus of the Holy Bible, Moses' father-in-law, Jethro, sets forth a treatise of organization principles. Industrial engineering did not come into its own, however, until the mid-nineteenth century, when men such as Charles Babbage, Frederick W. Taylor, and Henry Gantt studied and solved simple production problems.

In the early twentieth century, work that could be called operations research was done by Thomas Edison, A. K. Erlang, and Horace Levinson. However, O.R. as it exists today was not formalized until World War II. In fact, the term "operations research" stems directly from military lingo. In a military sense, operation means "the activity of a large military group to obtain a specific objective; an operation consists of a number of battles and encounters." In 1939, groups of British experts from various disciplines (mathematics, physics, psychology, logic, etc.) were formed to analyze military operations. These groups had appreciable success, and the United States and other Allied nations soon caught on. During the war, O.R. teams solved the problems of combating German submarines, determining the size and type of shipping convoys, and utilizing the merchant navy for military purposes.

However great the specific problem solutions during the war may have been, the greatest step forward was the development of general methods. After World War II, these methods were recognized to be applicable to the technical-economic problems in civilian life. Operations research as it is now known was begun.

THE METHOD

There are two major phases with which the operations research method is concerned. These are, in the order in which they must be considered, formulation of the problem and construction of the model.

The Problem

Formulation. Though it may seem obvious to people who have studied the Scientific Method, the first step in an O.R. project is formulating the problem. Everyone has often observed that people tend to leap right into the solution of a problem before even defining it, with the result that much time and effort is wasted by attacking the wrong problem. An excellent example of this tendency is the student who attempts to plug values into an equation which appears on a textbook page without first checking to see if the conditions of the equation are satisfied by the problem statement.

The formulation of the problem is often the most difficult part of the O.R. method. Operations research tries to provide the best solution for an entire system; since methods of coping with the system as a whole are usually too complex, the problem must be reduced to that of coping with a part of the system which is felt to be most critical.

Objectives. Closely linked to the formulation of the problem is the determination of the objectives. In a capitalistic society such as we live in, maximization of profit (or minimization of loss) is usually what is strived for. However, other criteria may also affect the objective. For instance, a man may want the job which will pay him the most money, but may also desire to live in a certain section of the country, to have an impressive-sounding title, to marry the boss's daughter, etc. A measure of effectiveness must be established for an explicitly defined problem; then, and only then, a a mathematical model can be constructed.

The Model

A scientific model is a representation of a system which is used for prediction and control of system events. The model is intended to facilitate determination of how changes in one or more aspects of the modeled system may affect other aspects. It is much more desirable to change variables in the model than to experiment on the actual system, mainly because of time and cost factors.

Types. There are two types of models which are of interest: iconic and symbolic models. An iconic model is a physical representation of a real-life object, either in idealized form (such as a photograph) or on a different scale (such as a globe). However, these are of little use in dynamic situations, such as the operations of a factory.

Symbolic models are abstract, rather than concrete like iconic models. Symbolic models include graphs, equations, and charts, and incorporate figures, symbols, and mathematics. This is the most precise and flexible model in dynamic situations, and is most often used in O.R. projects.

Construction. To continue the O.R. method, a model must be constructed after the problem and objective is defined. This is the stage where the most intelligence and ingenuity must be used by the operations researcher. The general form of the O.A. model is as follows:

Let E represent the measure of effectiveness to be used, based on the objective sought. Let X_i represent the variables which can be controlled in the system, and let Y_j represent the variables which cannot be controlled. Then, in constructing the model, one or more equations are formulated of the form

$$E = f(X_i, Y_j)$$

Solution. If the model closely approximates the real problem (which is what the operations researcher strives for), the solution of the model which determines the values X_i for which E is maximized will also yield the optimal solution of the real problem.

There are many methods of solution for mathematical models, involving several different types of mathematics and statistics. The most often used method is the analytical solution using differential calculus. If $E = f(X_i, Y_j)$, the partial derivative of E with respect to X_i, for all values of i, is taken and set equal to zero. The resulting equations are solved simultaneously (using simple algebra) for the optimal values of X_i.

Numerical solutions consist of substituting numbers for the symbols in the model and finding which set of numbers yield the maximum efficiency. This interative, trial-and-error process is used when differentiation of the effectiveness function is difficult or impossible.

There are several relatively new methods of solution for O.R. models, dating from the early twentieth century. These include the Monte Carlo technique, which is a statistical random sampling procedure; linear programming, which is used when restrictions and limitations are imposed on the model; and the theory of games, which describes how people should behave in competitive situations.

Difficult solutions of complicated models, which often are closer approximations of the real world, have been recently made easier to obtain by the advent of electronic data processing. Computers are generally recognized as a boon to both science and industry, and the field of operations research is no exception to this precept.

Implementation and Feedback. After the optimal solution is obtained from the model, it needs to be implemented. The solution must be translated into a set of operating procedures capable of being carried out in the real world. This step is fairly easy if the model is a good, clear one.

However, this is not the final step in the O.R. method. A control system must be devised which will allow for feedback of any variations in the conditions of the total system. Human nature tends to have people assume that once a problem is solved, it will remain solved and need no further analysis. But the real world is a dynamic one, changing with time, and the O.R. method must provide for changes in the parameters of the model and consequent changes of the solution. Again, modern data processing equipment is useful. If the model can be programmed for a computer, periodic checks on the validity of prior solutions can be readily made by feeding the present parameters into the program.

The method of operations research follows the general approach of the Scientific Method. Its specific steps are: (1) formulation of the problem; (2) determination of the objective; (3) construction of a model; (4) solution of the model; and (5) implementation and control of the solution.

USEFULNESS IN INDUSTRY

The analytical solutions obtained by operations research are superior to the intuitions of strategists in complex situations, since they obtain optimum answers to problems. Since industrial management is concerned with using productive, financial, and personnel resources for optimization of final profit, the O.R. method would seem well suited for use by management. This is in fact the case, and operations research is becoming increasingly popular as a tool used by management in decision-making.

Management Decision-Making

Management decision-makers have traditionally relied upon accounting methods to evaluate and control their systems. However, the criteria provided by accounting consist mainly of a series of checks on costs. No data is supplied which would allow a decision to be made between alternative courses of action. The only information given is an indication of whether or not costs are under control. As was noted earlier, the control system is only the final step of the O.R. method. Operations research provides management with quantitative data upon which to base its decisions.

Problems in Industry

There are many types of problems in industry which the O.R. method is capable of solving. Models and their solutions have been developed for most of these problems and are readily available for use by management. The problems include policy decisions on inventory, bidding, purchasing, replacement of assets, allocation of resources, testing and quality control, marketing, and transportation of goods.

For example, if a company wants to know how to bid on a certain contract to maximize its expected profit, it should use on O.R. analysis of a bidding model. If the company bids too high, it won't receive the contract and the profit will be zero. If it bids too low, it may receive the contract, but the profit will probably be very small. Operations research yields the value of the best in-between bid, which will maximize the profit he can expect to get.

SAMPLE MODELS

Two of the more well-known operations research models are the following: (1) Inventory models, which aid in controlling ordering and carrying costs; and (2) Replacement models, which give the optimum period of service for a unit, after which replacement becomes advantageous. There are of course many other models which are in use in one form or another, but these two are the most commonplace and shall be briefly explained.

Inventory Model

Inventory control is both a common concern of management and an important one. For many firms the inventory carried is the largest single current asset; more money is tied up in supplies and raw materials than in machinery or buildings.

The two basic decisions involved with inventory control are as follows:

1. How much to order at one time?
2. When to order the quantity?

The model presented considers a greatly simplified concept of an inventory problem. A firm will be considered which requires a specific quantity of a purchased product over a specific planning period. Assume that these products are used up at a constant rate, that shortages are not permitted, that the product quantity is received immedicately after it is ordered, and that the unit price of the product does not vary.

Let
Q = quantity ordered at one time
T = time between orders

Let
R = total requirement of product
L = length of the planning period

This model can be represented graphically.

Then $\frac{R}{Q}$ = the number of orders during time L

$$T = \frac{Y}{R/Q} = \frac{YQ}{R}$$

The two important costs involved are the ordering cost and the carrying cost. Ordering costs are incurred each time a quantity is ordered, no matter how large or small the quantity is. They include stationery costs and costs of personnel time needed for requisitioning, receiving, and storing the product.

Carrying costs include interest on the money tied up in inventory, space rental, and taxes, insurance, and depreciation on the inventory.

The actual price per item, P, is not a factor in this model, since the total price paid for the product over the

(Continued on page 38)

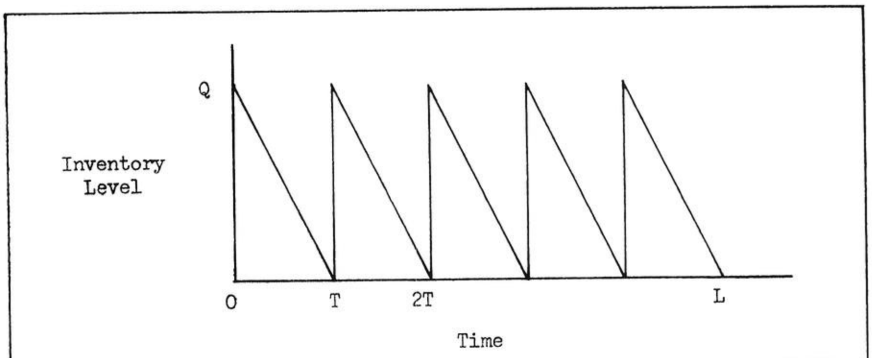

Figure 1. Inventory Level vs. Time

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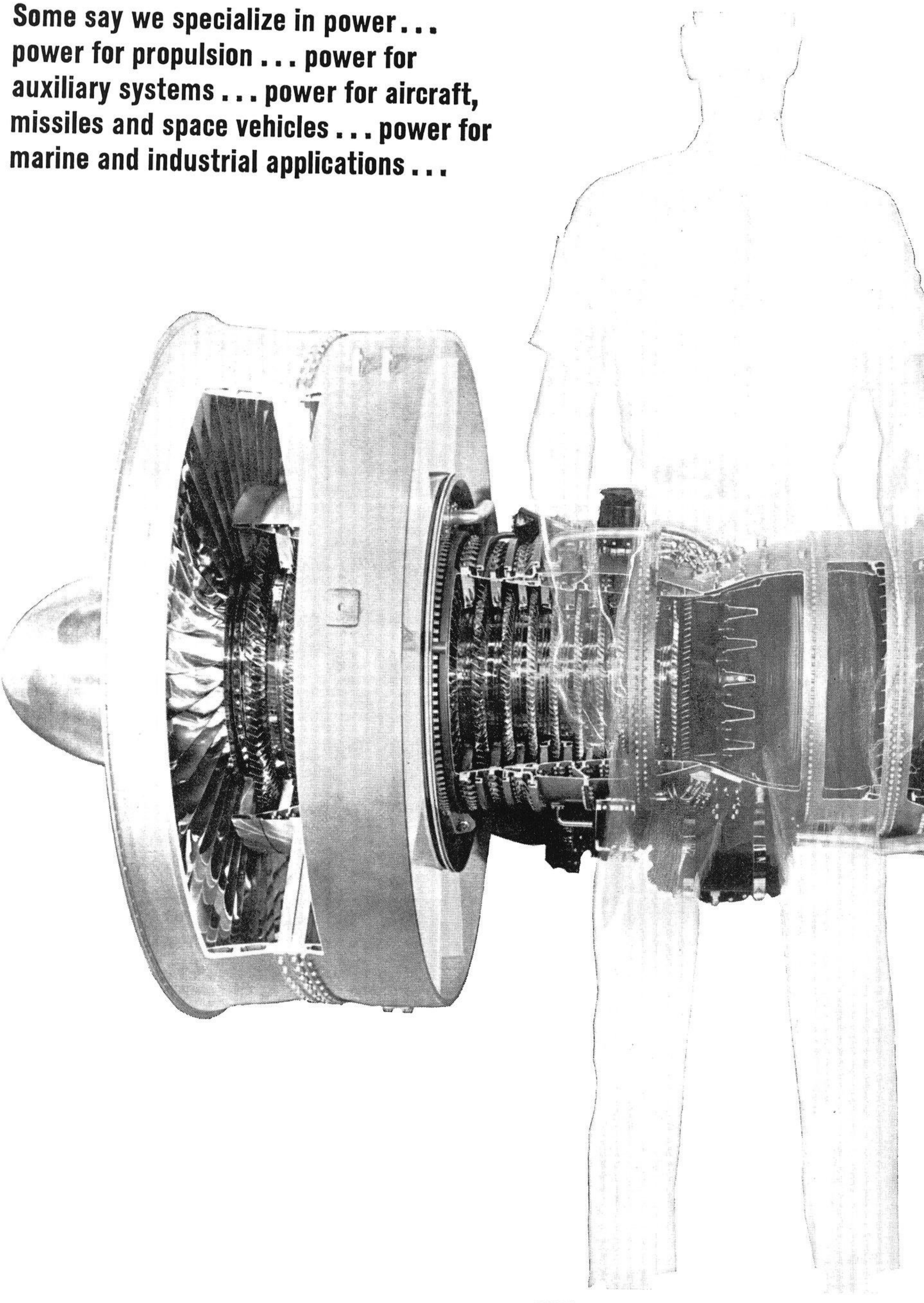

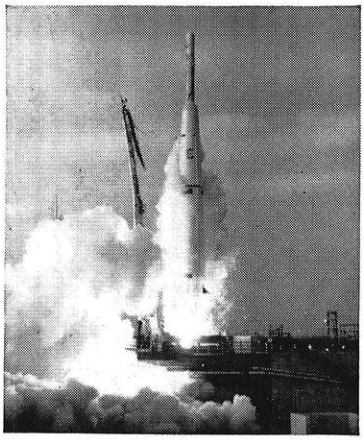

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THE GAMES THE BIG MEN PLAY

by Greg A. Bott

Management is a popular topic of conversation among seniors around the campus. Many of us see management in our professional futures, but we have a hard time defining its function. Business has even more difficulty in deciding what it takes to be a good manager. The importance of good management is obvious and so vital to business that it has turned to an educational tool to select and improve its managerial ranks. The sudden and increasing popularity of simulated management games has paralled the emphasis on further education by most companies. Any professional person in industry will come in contact with some form of these games.

The historical roots of management games are as interesting as the games themselves. These roots, along with the needs of business and educational institutions, are traced in the following paragraphs. The forms of these games and their educational benefits are classified and explained. The effectiveness of their function and acceptability by participants is also generalized on.

Following these general statements, a specific development of the problems involved in the design of management games is presented. A general example of a game is followed, finally, by a brief conclusion.

SIMULATION DECISION MAKING

Technology is a field that is increasing at a fantastic rate. Companies are becoming more complex and products more technical. Computer, transportation and communication systems create a smaller, faster and more complicated world. How is business adjusting to this dynamic environment? Responsible managerial ranks are the answer. How does business develop this talent? The Management Game is one method.

Business has indicated its need of responsible management talent in the unbelievable rise in the popularity of management games. The reasons for this interest in management development are varied and come directly from the pulse of industry. Large - scale corporations require complicated decisions and the necessary insights into complex situations. The compeitive pressures, internal and external, of business make good decisions vital. The many different skills involved in these decisions are available to present and future managers.

Emphasis on further education in business began in the early 1950's. This took the form of back-to-school programs or education on company time. At this same time computers were becoming more useful in educational areas. American Management Association, AMA, finally came out with the first management game; and along with the educational trend in management, these games have found rapid success in both educational and business institutions.

HISTORICAL ROOTS

Simulation is a form of modeling that has long been used in experimentation. A model is used when the real - life world can't be measured or influenced by a measurement. The trial - and - error process used in simulation is a necessary basis of the learning process which models provide with no error costs.

The areas simulation grew out of included military gaming, operations research, and educational advances. The military used the games to determine strategy under common situations and to analyze optimal results. Improving a given real-life system or designing a new system was the simulation purpose in operations research. Obvious educational opportunities arose from these practical uses.

The simulation exercise that satisfies this educational need is titled by a confusing phrase, business gaming. "Sequencial decision making exercise structured around a model of a business organization in which participants play the role of managing the simulated operation" seems to be as complete a definition as possible. Although the term "management games" is often used, the word "game" is extremely misleading. The dynamic nature described in its definition is the key to success when used for training.

From the first games, developed by AMA and the Rand Corporation in 1957, the popularity and variations in management games have been overwhelming. There are now well over 100 unique games and, with variations of each, it would be impossible to tell how many games might be available. The number of games alone indicate the business and educational reliance on them as a teaching tool.

MANAGERIAL SCOPE

Decision - making under pressure with limited information is the environment of a manager. Add the interaction with people and the simulation would be complete — or would it? The management games have limitations and must be tuned to specific needs and well defined in scope. What are the business and educational needs in this area? The danger in making the game too complex might be that the player must go to the real world to practice for the game world.

Two general classes of simulation models are the general management and the functional. The general games may simulate a typical company in a particular industry or a specific company in that industry. These models are developed by a corporation for the development of upper-management in total industry concepts. Their use has been found to be easiest in the industries where there are a large number of competitors, none of which can influence the market. The opportunity to make broad financial decisions is the prime value.

The functional games cover a broad area. They might cover general functions such as marketing, inventory control, and production scheduling. The recent trend is toward games covering a specific job area for training purposes. Situations ranging from running an airport to buying animals in the stock exchange show the variety of functional games. Here specific market conditions and similar decision pressures may be modeled. The game may emphasize a specific decision-making process. The time dimension will create pressures, while feedback to the player make him aware of mistakes and areas for improvement. These games must have balance btween long term and short term decisions with a competitive environment and pressures on future growth. The educational benefits seem to lie here for specific training in industry.

Educational objectives in either type of game are as follows:

1) Planned, timely decisions produce realistic pressures and frustrations.

2) The need for an organized effor brings in the human involvement problem.

3) The use of decision-assisting tools may be seen in action and the results evaluated.

4) The dynamic balance of the management function may be easier to see in a short time span.

5) From both the administrator's and participant's view, the power of the modeling concept can be seen.

The well-designed game seems to be effective if judged by the number of games in existence and the enthusiasm of the participants. It is interesting, however, that there has been no research into the actual educational value of simulation, when used in teaching. Does the participant improve his real-life decision-making process? This is an area yet to be justified.

The computer industry has done much to promote the use of management games. In universities and business, valuable computer time must be used to best purpose. Management games seem to have sold. The design of these games is critical to the success of the game. Here the computer industry and educational institutions have been instrumental in the improvement of design for better and more specific use.

DESIGN OF MANAGEMENT GAMES

With the areas of need having been defined and the ends of management games in sight, the design of this tool is feasible. The initial phase of design involves the gathering of real-world statistics and applying accepted theory to this data. Setting up the rules and relationships for the highly complex structured mathematics involved between the decision and the outcome is the test at hand. The practicality and compromise now begin where ideal concepts have ended.

Objectives

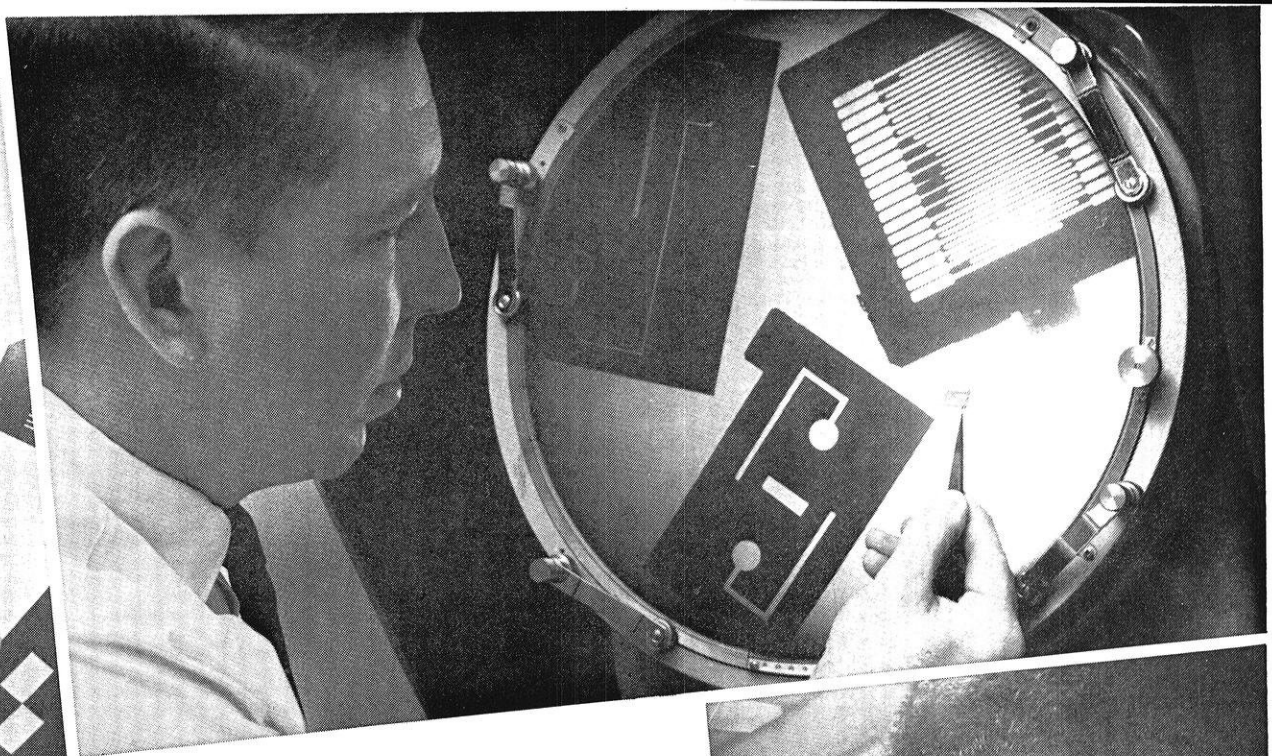
The first step in designing a simulation is determining its educational objectives. Does the designer want to emphasize multiple decisions? To what level of management will the game appeal? What kind of feedback does he want to give the players as well as himself? Will there be group or individual decisions? Will the decisions be interactive or independent? The designer will determine the pre - game information which will orient the players' thinking. The resources available as well as some measure of success will have to be determined. This is a sample of the complex objectives possible and the magnitude of the designer's task.

The model should be a simulation of the real world only to a limited degree. The designer must decide on which phases he will emphasize. Will he model an entire industry, a particular job function in any industry, or a generalized business in a typical economy? He will have to conduct his research and collect data based on this decision. Problems the designer may encounter here lie in unavailable market information, and communication difficulties in getting relevant information. The educator may find industry unwilling to divulge information and costly research may be necessary. The scope of the objectives will directly determine the complexity of the structure.

Structure

Three main considerations in the structure phase of design are realism, complexity and participant acceptance. Other factors affecting structure might be cost and time involved in preparation and play. There is a danger here of conflicting needs. For example, a high degree of complexity might interfere with participant benefits. If the player can't tell that the outcome of his decision came about through theories he has applied, the benefits of trial and error will not be appreciated.

The game must be complex enough to keep the players interested. In an interactive game, therefore, the decisions of one group influence the results of another, competing group. If the game doesn't seem realistic and isn't competitive, the player loses interest. Feeling of inadequate decision-making may be blamed on imperfections in the



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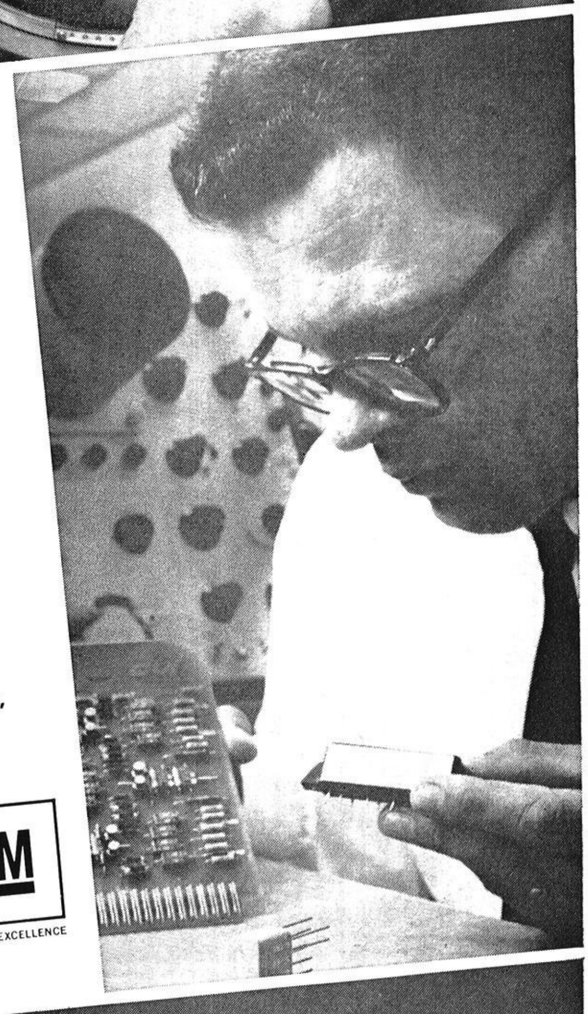


game. This indicates how the design may be critical in creating stresses, tensions and frustrations which complicate decision - making process.

A way to get around the problem of direct frustration with the game is to make it as realistic as possible. Keeping the player's interest in the simulated real-world situation is the challenge to a designer. An example of the illusion of reality is shown in AMA's general management simulation game. Here the players read a four-page letter from the chairman of the board listing the specific rules and procedures that were used by the late president of the company and suggest that these principles be carried on. The key is to induce the feeling of involvement.

Game Elements

The building blocks of a management game may be defined as its elements. The three elements that must be designed into any game are input, output and information.

The view of the designer should be that the decision of a company are the inputs and the operating results are the outputs. The number of inputs per period of play may vary with the complexity of the game. The outputs may be expressed in only profit terms or may be quite extensive covering sales, inventory and costs. The learning process may be enhanced by the chance to repeat decisions and learn by past outputs.

The major problem in game design is deciding what information will be provided to participants. There are five types of informational elements found in management games: (1) the players' instructions; (2) company operating statements; (3) market resarch information made available during play; (4) annual or periodic reports; and (5) predictive data which may be feed back to players from time to time.

The problem here is providing the right amount and type of information to keep the game interesting yet challenging. The designer must avoid revealing the relationship between the decisions and the results. He must clearly define game procedures and rules, along with a specific starting point into the play. The player needs an idea of what kind of decisions he will be confronted with. The danger of poor starting information leading to faulty initial decisions is the inability to recuperate in time. The beneficial learning process is the key the designer must consider.

A GENERAL GAME

The game session is quite a variable element. It may continue over a period of time up to a few weeks. On the other hand, it may be played once a week and last a considerable length of time. No matter how the sessions of play are conducted, the same basic ingredients are found. The following general example will show the phases a game should go through:

1) BRIEFING. This initial part of the session will give everyone involved a view of the type of company he will be functioning in as well as the product breakdown. The economic conditions of the past and present are explained. The function and general organization would be briefly discussed. Finally, the mechanics of play will be presented, although they may be covered in some of the previous material.

2) MEET THE TEAM. The group involved is divided into companies. Through discussion of their situation and prospective policies, they form some kind of basic organization on which to function. Here is the human side of the decision-making exercise involving delegation of power and agreement on policies. Controls, objectives and procedures are also determined during this session.

3) PERIOD OF PLAY. The period of play is usually equal to one-quarter of a year. A time limit of varying nature is given to make the required decisions. The team will receive reports on the previous period results. The profit after the predetermined number of periods will determine how well the team was managed. These periods may be broken by discussions, lectures or addition of knowledge with which the players will make future decisions.

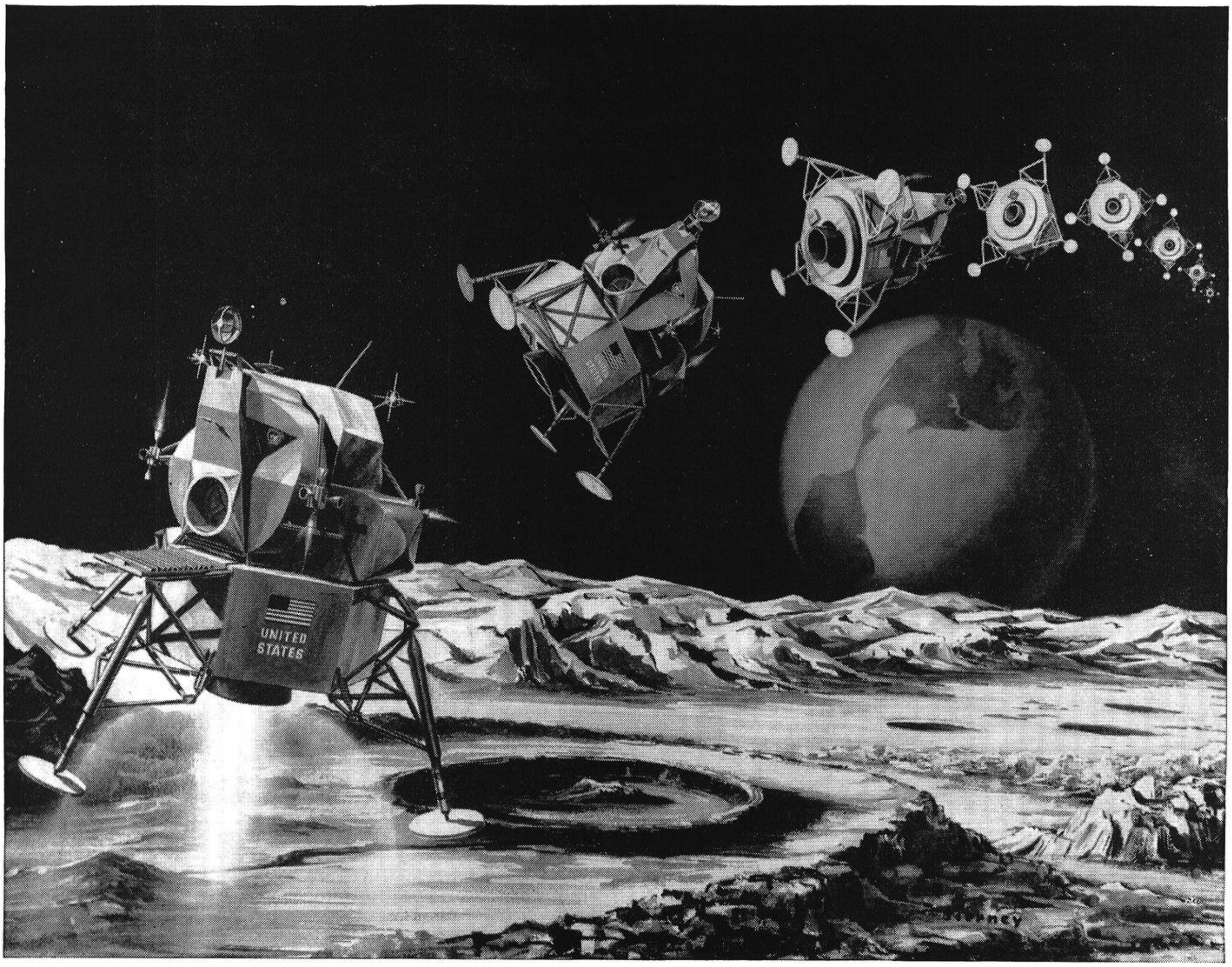
4) OBSERVATION AND FEEDBACK. The administrator of the game will have some means of observing the play and providing the team with information on their techniques. These suggestions may be in report form during the game and verbally after the game. The intent here is to point out tactical errors, personality conflicts and management blunders. Discussion by the team proves to be one of the strongest learning methods available.

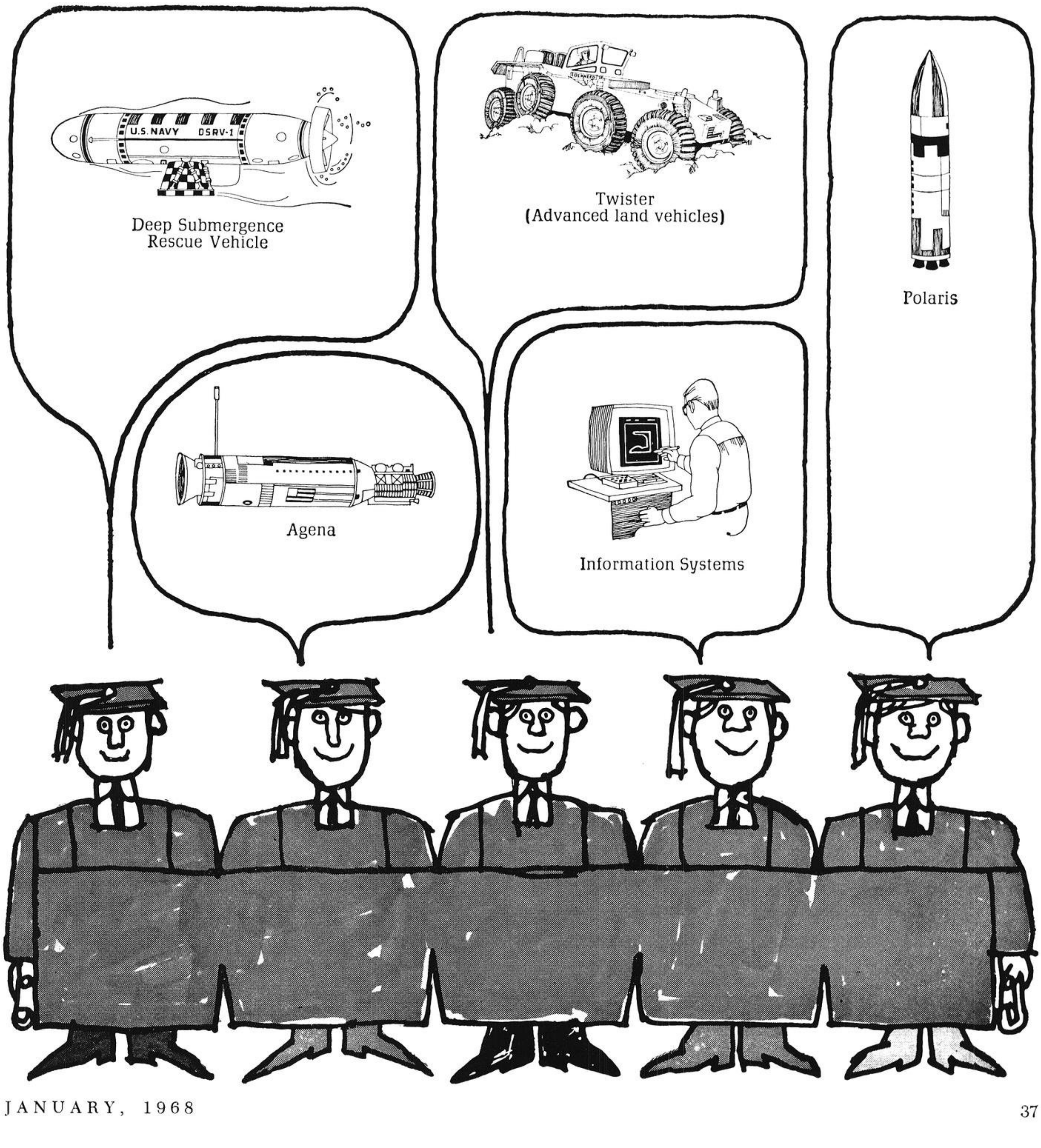
5) CRITIQUE SESSION. After the completion of play, all the groups discuss the results in an organized manner under the direction of the administrator. Involved here is a sharing of mistakes and successes and a general analysis of the game.

LIMITATIONS

Even though management games are quite popular, they have limitations. The most general limitation is the initial cost of the game. A large number of hours must be used in designing even the easiest of games. When computer time becomes involved, the cost gets extremely high. Many games have been developed in educational institutions and, although the design of the games may be an interesting exercise in computer logic, there has been no proof as to the educational value of the games themselves.

Because of the sudden popularity of management games, it has been suggested that they are a fad or an excuse to use or purchase computer time and indicate the level of advancement of the particular institution. Similarly, because of the general acceptance of the games, a participant might find his experience too limited to gain anything from the game. Here again, the games generally apply to large groups and the individual may be slighted. The success of management games today would indicate there is much to be gained from them.


UNITED
STATES


U.S. NAVY DSRV-1
Deep Submergence Rescue Vehicle
Twister (Advanced land vehicles)
Polaris
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time period under consideration is always equal to P times R.

The value of Q must be found which will minimize the total cost of both ordering and carrying costs over the period. If too few units are purchased at one time, more orders will be required and the total ordering costs will rise. If too many are purchased at one time, more units will have to be held longer, and total carrying costs will rise.

Let

C_1 = cost of holding one unit in inventory per unit time

C_2 = ordering cost per order placed

K = total cost over time L

From Figure 1,

$$\frac{Q}{2} = \text{average inventory during time L}$$

$$\text{Then } C_1 L \frac{Q}{2} = \text{total carrying cost over time L}$$

$$C_2 \frac{R}{Q} = \text{total ordering cost over time L}$$

$$K = \frac{C_1 L Q}{2} + \frac{C_2 R}{Q}$$

These costs are graphed versus the order quantity.

The method of solution of this cost model is that of differential calculus. To find the value of Q which yields the minimum value of K, set the partial of K with respect to Q equal to 0, and solve for Q. This yields the following solutions:

$$Q = \sqrt{\frac{2RC_2}{LC_1}} \qquad T = \sqrt{\frac{2LC_2}{RC_1}}$$

Suppose a firm uses a certain type of switch on its manufactured goods, and it is decided that these switches will be used up at the rate of 2,000 per month for the coming year. The accounting department states that it costs ten cents to store one switch for one month, and that the cost of processing an order is $400.00. This information can be summed up as follows, using the notation developed:

$$L = 12 \text{ months}$$
$$R = 24000$$
$$C_1 = \$0.10$$
$$C_2 = \$400.00$$

$$\text{Then } Q = \sqrt{\frac{2x24000x400}{12x.1}} = 4000$$

$$T = \sqrt{\frac{2x12x400}{24000x.1}} = 2$$

The optimum policy for this firm is to purchase 4,000 switches every two months.

As was stated before, this is a very simple inventory model. It is probably also not very realistic. In the real world, products are not used up at a constant rate, shortages do occur, a lead time is associated with ordering, and quantity discounts are given to purchasers. Models do exist for inventory problems with various other assumptions and restrictions. Solution of the models is carried out much like the one presented here. An expression for total cost as a function of order quantity is determined and the order quantity which minimizes the total cost is found.

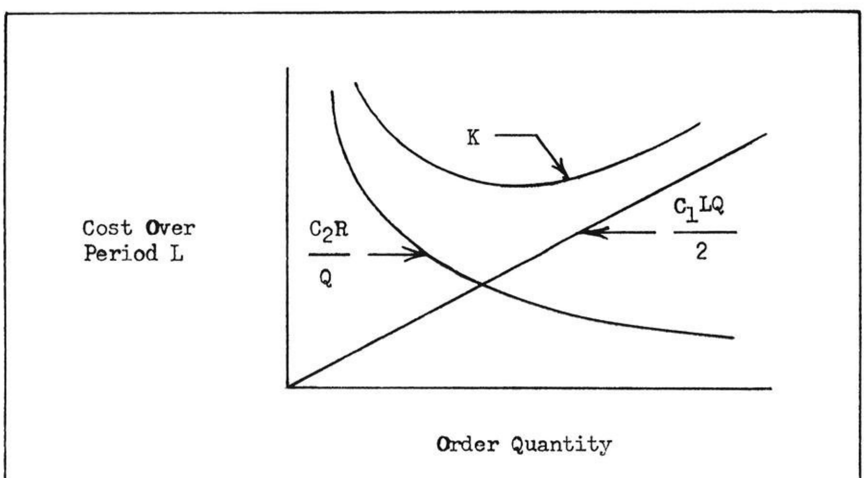


Figure 2. Total Costs vs. Order Quantity

Replacement Model

Management must also be concerned with assets that need to be replaced periodically, such as machine tools which deteriorate and light bulbs which fail. Types of replacement models fall into two distinct categories:

1. Prediction of the time when an asset becomes inefficient enough to warrant replacing it with a new asset.

2. Prediction of the most economical replacement policy for a group of items that have a probabilistic life span.

Because of space limitations, this report will illustrate a model only from the second group, that of items which fail after a period of use.

The assumptions of the replacement model given here include the following: (1) the cost of the item itself is small relative to installation costs; (2) there is a life span associated with the item which can be expressed in terms of probabilities; (3) items are replaced immediately after they fail; and (4) the cost of replacing an item when it fails is greater than replacing it before it fails.

Perhaps the best example of a situation which fits this model is that of a chemical-producing plant which uses many pumps to move the chemicals from one process to another. These pumps either work well or fail completely when a gasket, impeller, or some other part fails. A probabilistic life span can be reasonably assumed, and data on this life span can be collected from past failure records. If p(t) is the probability that a pump will fail luring period t from when it was first installed, a chart of p(t) for the pumps might appear as shown.

p(1)	p(2)	p(3)	p(4)	p(5)
.05	.20	.40	.25	.10

Figure 3.
p(t) = probability of a pump failing in period t

Note that the sum of the probabilies is 1.00, which must be true if it is assumed that all pumps must fail eventually. The period may be any convenient time span. For the chemical plant it will be taken to be one month, since the end-of-the-month maintenance schedule would allow a good time to replace things.

In this instance, it is easy to see why the cost of a failure is more expensive than the cost of replacing the pump at a planned maintenance time. If one pump quits working, an entire process string may cease and not be productive again until the pump is replaced. The resulting shutdown of the process means that expensive machinery and labor must stand idle during the time the pump is inoperative. The cost per pump of replacing all pumps at the end of a period is much less, since this preventive measure can be done while the process is shut down for other planned routine work.

If the model is begun at time zero, with all items being new, the important factors are as follows:

C_1 = unit cost of replacement in a group
C_2 = unit cost of individual replacement after failure
$f(X)$ = total number of failures in period X
N = total number of units in the group

To simplify this particular model, it is also assumed that all items are replaced at the end of some time period T, even if they failed and were replaced just prior to the end of T.

Using probability theory, it can be shown that

$$f(X) = N\{p(X) + \sum_{t-1}^{X-1} p(t)p(X-t) + \sum_{j=2}^{X-1}\sum_{t=1}^{j-1} p(t)p(j-t)p(X-j) + \ldots\}.$$

For example,

$$f(3) = N\{p(3) + p(1)p(2) + p(2)p(1) + p(1)p(1)p(1)\}.$$

Then the average cost per period, $K(t)$, for a policy specifying complete replacement at the end of period t is:

$$K(t) = \frac{C_1N + C_2\sum_{X=1} f(X)}{t}$$

Since $f(t)$ is a very complex function, the solution for this model is usually found by calculating $K(t)$ for all values of t considered and finding which value of t minimizes $K(t)$.

Suppose the chemical processing firm mentioned earlier has the probability distribution of life spans as shown, for the 100 pumps he uses in his process. Then the values of $f(X)$ will be as shown in Figure 4.

f(1)	f(2)	f(3)	f(4)	f(5)
5.00	20.25	42.01	33.15	29.41

Figure 4.
f(X) = average number of pump failures in period X

Also suppose the costs are determined as follows:

C_1 = \$100.00
C_2 = \$1000.00

Using the model developed in this report, the tabulated results are shown.

K(1)	K(2)	K(3)	K(4)	K(4)
\$15000	17625	25753	27602	27964

Figure 5
K(t) = average cost per month for complete replacement at the end of period t

From these expected cost figures the rather startling observation is that the chemical plant should replace all of the pumps at the end of every month, even though 75% of the pumps would still have another period's use in them, and it would cost them \$10,000.00 every month for planned replacements. This example illustrates the usefulness of operations research in showing management in quantitative terms just how much a given policy compares with other seemingly better policies.

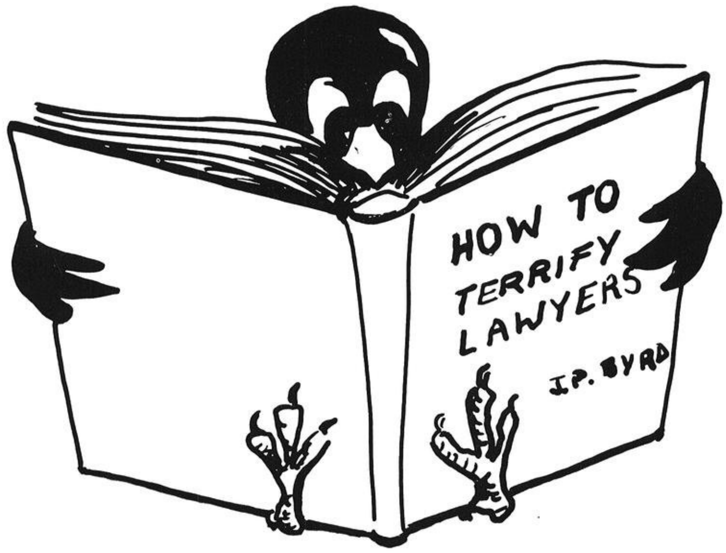
It should be emphasized that the models presented here and in other sources are not designed to be used blindly. They are intended to be used only as a guide to the type of analysis which the operations researcher should make.

There is one other point worth noting about operations research models. While it was stated earlier that accounting methods do not give management enough information to make quantitative decisions, accounting does provide many of the cost figures that are used as parameters in O.R. models. The accountant accumulates cost data over a long period of time, making extrapolation of future cost for a specific operating parameter easy to obtain. For example, a percentage carrying cost per dollar value of any item per unit time can be found by adding up all storage and interest costs for several periods, and dividing this figure by the total purchased price of all items which were stored times the number of periods. Multiplying this percentage by the cost of the item in question will yield the cost of holding one unit in inventory for one period.

FUTURE OUTLOOK

Operations research is a relatively new branch of science, and the knowledge about it is continuing to expand. Evidence of its rapid growth is the proliferation of technical literature about O.R. which has been published within the last ten years. Students in universities and men in industries are extending the O.R. method to more and more phases of the economy. They are using more complicated models and more exotic solution techniques to achieve closer approximations of the real world. As the field of computer sciences grows also, O.R. models become more easily solved and adapted for use in the economy. And in the demand for operations research promises to keep pace with the research activities.

Today's businessman can no longer rely solely upon his experience and judgment to make decisions if he hopes to stay in business. The technology explosion forces the businessman to look and plan ahead, lest he be left in his competitor's dust. Decisions must be carefully thought out and based on quantitative analyses. This trend will continue, and it appears that operations research will satisfy the demand and will be used even more extensively in the future than it is now.



BYRD SCRATCHES

By J. P. BYRD, B.S. '69

By the time the engineer graduates from college he has successfully completed 6 credits of English. Later, when he finds himself part of the world of machines, materials, structures, and power, he is required to report not only on his activities, but also on those under his direction. He then finds finds that the essay type English studied in college is not adequate because it doesn't give him the background necessary for factual writing.

The engineer, then, is not a writer but a factual reporter driven to reporting by the situations arising in his world of facts and the necessity of informing his superiors of these situations. As a student he found that his laboratory work and observations meant nothing to his instructor unless the data was clearly organized and presently in the form of a written report. On the job he finds that his ability to express his opinions and interpret his results in writing is a major item in his professional advancement. He writes because it is necessary to his existence as an engineer.

The engineering student often feels, toward the end of his college training, that he lacks the facility for expressing himself that characterizes students preparing for other occupations. His instruments of expression are largely technical facts, codes, and drawings. He incorrectly assumes that all the people he must work with and who read his reports understand and can interpret these facts, codes, and drawings. Since he has limited training outside of his technical world, he lacks the ability to express himself outside of his sphere. Like the good engineer he is, he must recognize and try to overcome these limitations.

The engineer's, like the salesman's, study of English involves the best ways of presenting and selling his products. He must be able to sell it, either orally or by the written page, adapting his approach to the product, market, and the customer.

The student's first opportunity to show his ability to sell his product is in his junior and senior years of college. In these years the student is required to transmit his knowledge and understanding to his instructors through the medium of written reports. He must sell his product. No student has ever gained a full understanding of his subject unless he can state his knowledge in a clear, well-organized form, understandable to others.

The prospective engineer's next contact with report writing occurs during his first months of college. He finds that his writing is a means whereby his superiors measure his aptitude, powers of observation, and achievements. He records his work so his superiors gain not only a measure of his knowledge and personality, but so that they also may have data and conclusions ready for the needs of the organization.

The engineer, once established, realizes the importance of being able to express himself clearly and concisely. Any work he undertakes, any proposals he makes must be written out in minute detail before his employer can be convinced of their need and authenticity. He must, therefore, be able to express himself on paper in terms that can be understood by a variety of individuals.

Hard experience and long hours can give the undergrad engineer this ability, but why must he be forced into these conditions? His early writing instruction ends with freshman English essays, and this instruction is not resumed until in his senior year he is faced with a technical writing course. The placement of this last course seems backward when considering the number of technical papers the engineer has already completed.
A sophomore course in technical writing should be considered. More experience may be gained as the engineer may apply the principles he has learned in his sophomore year to college papers. Why would the engineer spend two or three years making attempts at writing lab reports and then be taught how??

J. P. Byrd →

Engineers, Mathematicians:

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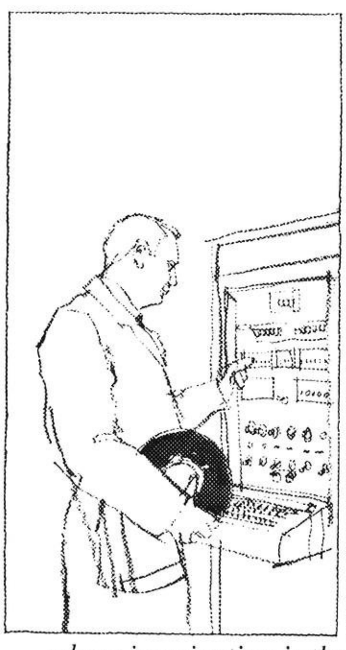

. . . where imagination is the essential qualification

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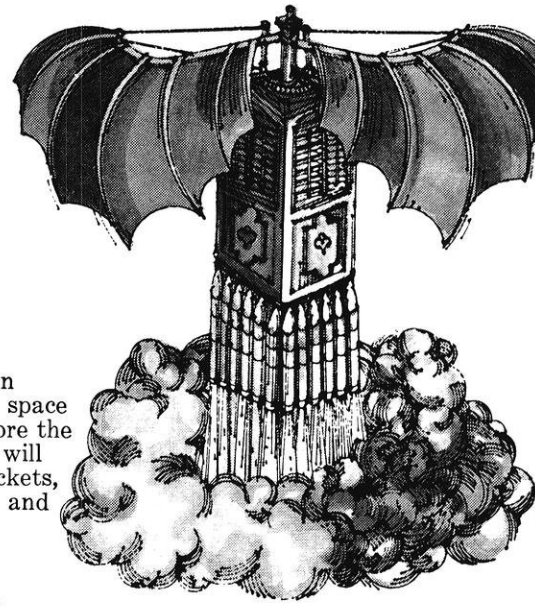

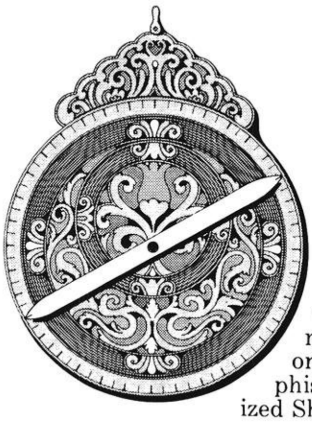

17th-Century Space Flight. Cyrano de Bergerac's science fiction fantasy about a box propelled into space by rockets came close to fact. Before the end of this decade, Apollo and LM will indeed be thrust to the moon by rockets, guided by AC Electronics guidance and navigation systems.

Navigation, Second-Century B.C. Hipparchus's second-century astrolabe was used for celestial navigation until the mid-18th century. Today, ships still depend on stars for guidance . . . through such sophisticated help as AC Electronics' computerized Ships' Self-Contained Navigation System.

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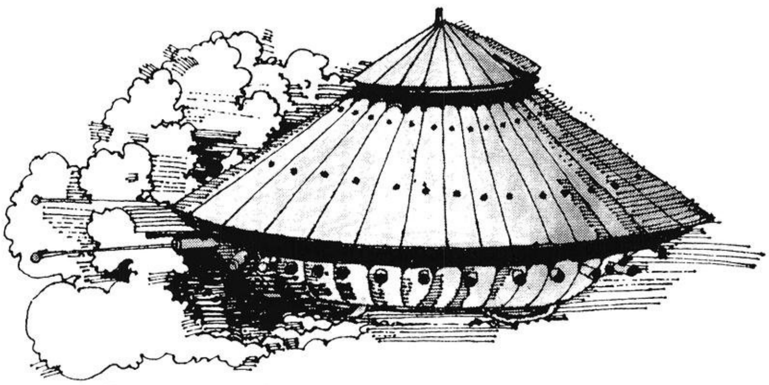
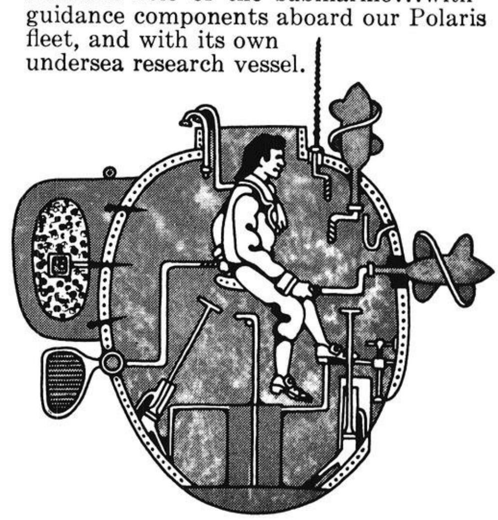
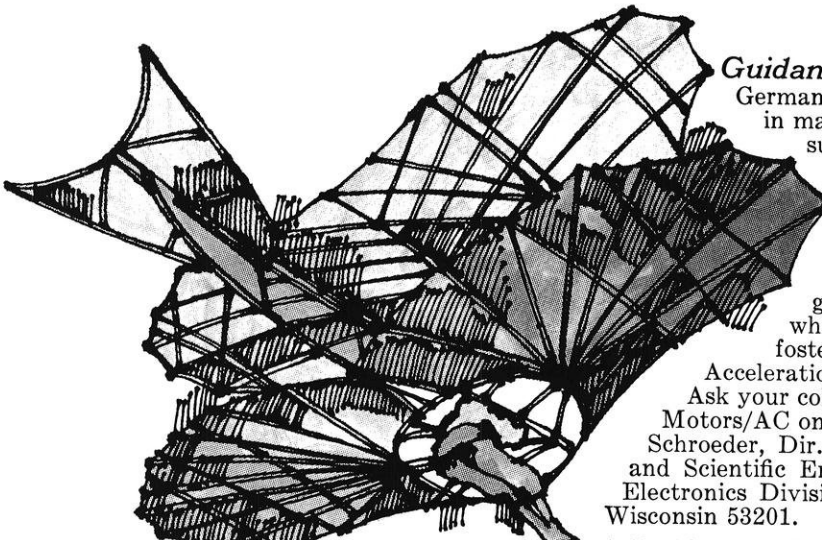




Leonardo's Tank. Leonardo da Vinci was one of the first to envision the use of tanks in warfare. Contributing to the advanced state-of-the-art in tanks, today, is AC Electronics, with a computerized fire-control system for military land vehicles.



Guidance Gets a Lift. Otto Lilienthal, 19th-century German glider, proved that the future of flight lay in man's ability to guide the aircraft. Tomorrow's superjets will be guided inertially . . . by systems like AC Electronics' Carousel IV, chosen for the Boeing 747.

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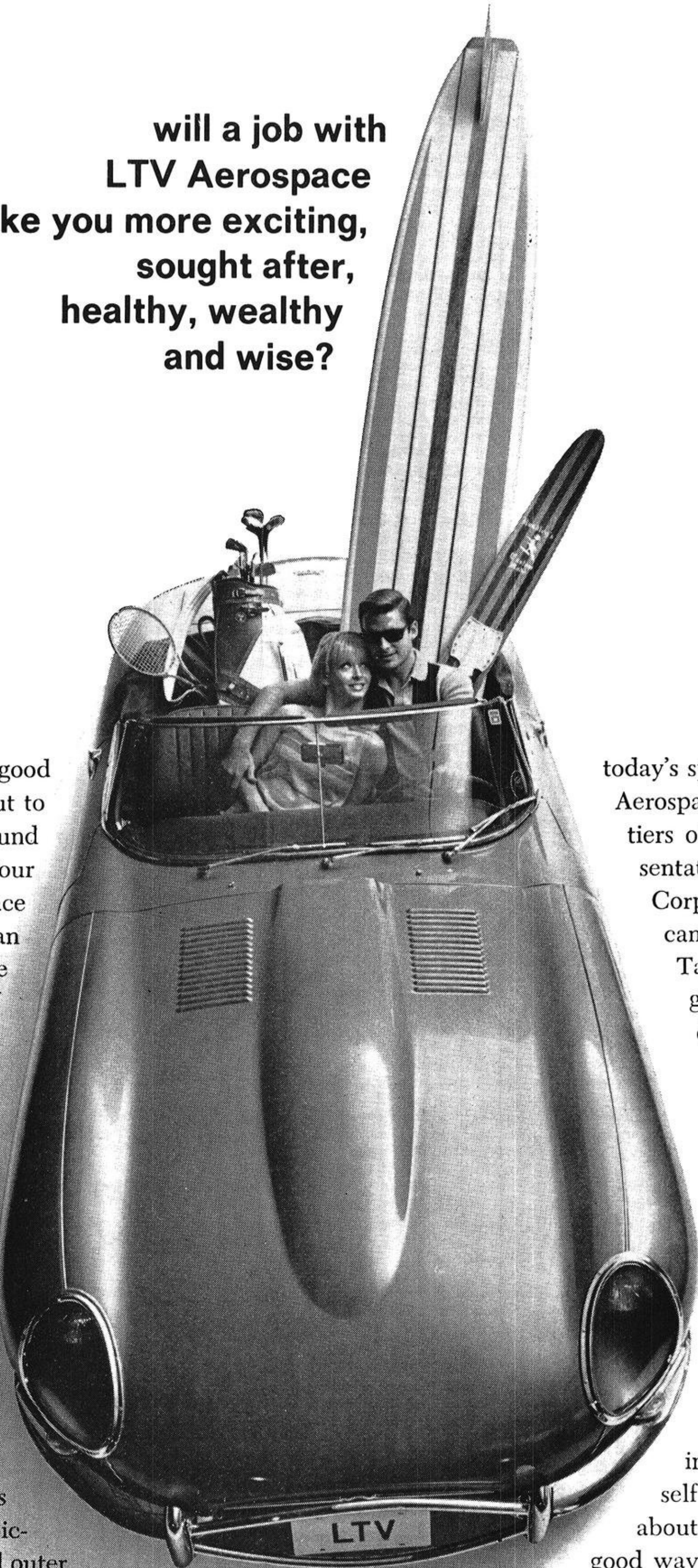

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The *Wisconsin Engineer* is happy to present (with fanfare, etc., etc.), Sally Mathers as Wisconsin's Finest for January. A very interesting freshman majoring in "I don't know yet, but it won't be engineering," Sally is a Wisconsin native interested in "everything." She has one major hung up. She thinks that the little old Volvo that she drives is "pretty." What do you do with a girl like that? We suggest having fun!

Photos by Norm Frater

wisconsin's finest presents

SALLY MATHERS

Randy Trost, Wisconsin '67

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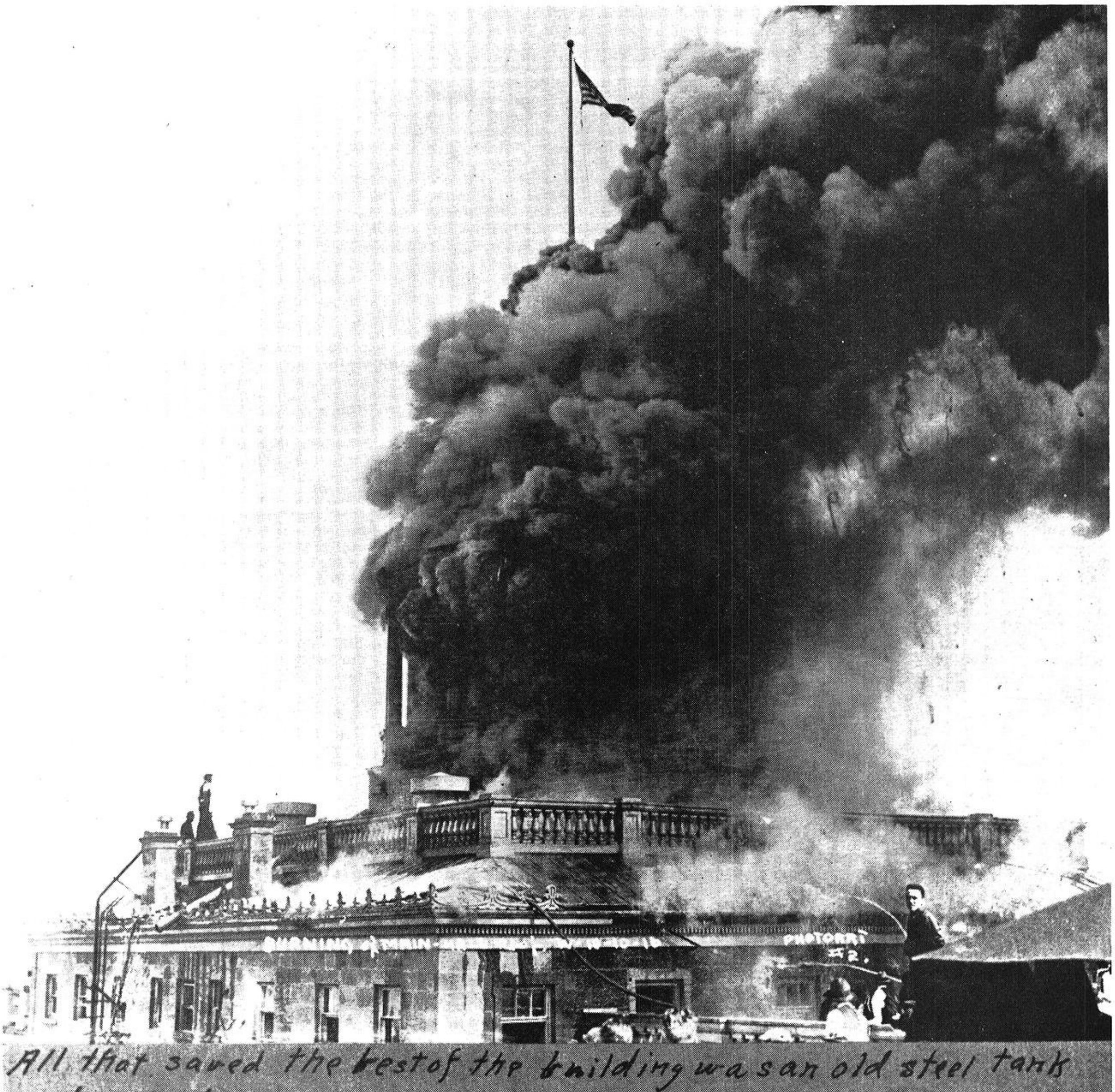
PICTORIAL

wisconsin's album

THE BURNING OF BASCOM



Fire Up for Finals!


CAREERS WITH BETHLEHEM STEEL
54
CAREERS WITH BETHLEHEM STEEL
30

"Yeah, I was in Engineering once . . . "
from Illinois Techograph

HUMOR

FILEABLES

A girdle is an elastic supplement to stern reality.

* * *

Statistics show that Vassar graduates have 1.7 children, while Yale graduates have 1.4 children on the average. This proves that women have more children than men.

* * *

Dames are pushovers for gay caballeros. Caballeros are athletes in Spain. Athletes in Spain throw the bull for diversion. Therefore dames are pushovers for bull throwers.

* * *

Which reminds us of the IBM salesman who dropped LSD. He went on a business trip.

* * *

Did You Hear About:

The street cleaner who was fired for day-dreaming? He couldn't keep his mind in the gutter.

The butcher who backed into the meat grinder and got a little behind in his orders?

* * *

In case you find a mistake in this magazine, please remember it was put there for someone's benefit. We try to please everyone and some people are always looking for mistakes.

* * *

He: "Do you neck?"
She: "That's my business!"
He: "Ah! At last, a professional!"

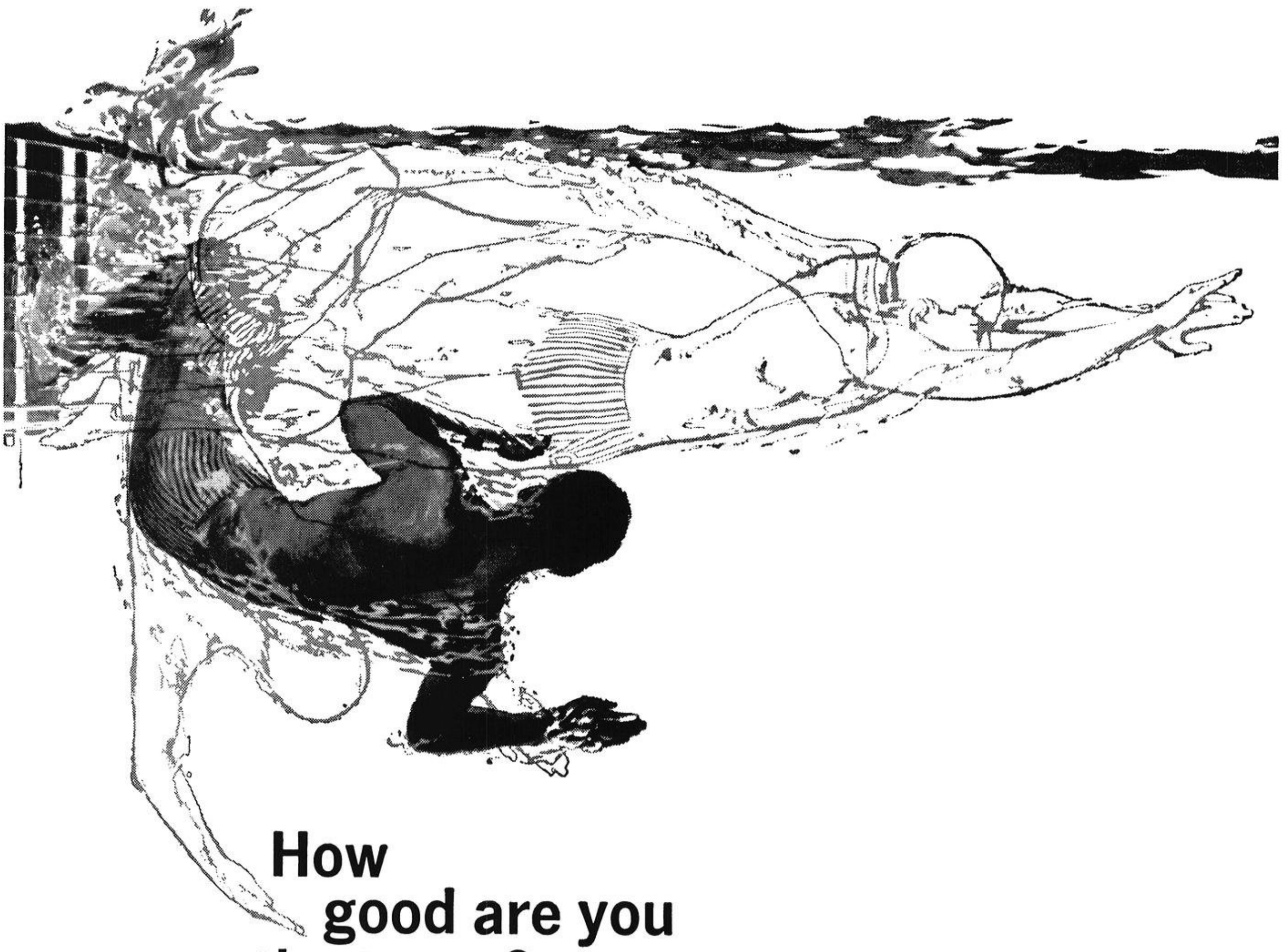
* * *

Whoever said "Live and Learn" was a dreamer. At this school we have time to do one or the other, but not both.

* * *

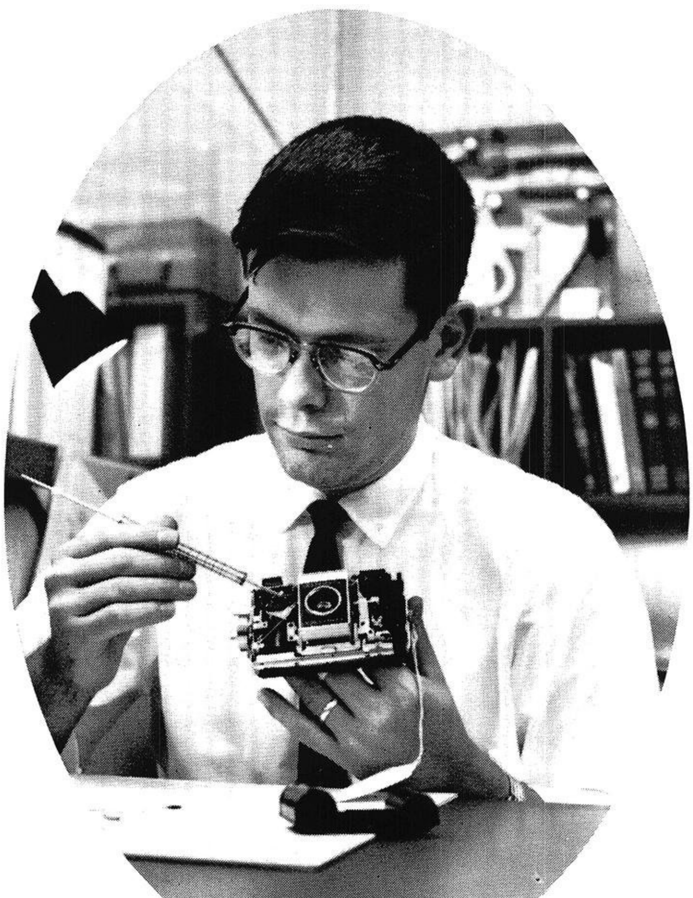
"Winter draws on," said the Harvard man as he tucked Muriel in an old fashioned sleigh.

"Is that any of your business?" Muriel asked coldly.



Kodak

This is the image of a Kodak mechanical engineer



Correct, literally. But misleading because Larry Wood's job is not typical of Kodak engineers in general. Most of them get to handle a camera—assembled or disassembled—only at home or on vacation. Unless they happen to be personally hipped on cameras (which Larry once told us he is).

Diversification has been going on here for a long, long time. That's why we can give an engineer plenty of solid ground for choice—at the outset and later. If his personal feelings incline him away from devoting his talents to fun things like cameras, he gets just as good a chance to demonstrate his capacity for higher responsibility through work in the 72% of our business that has nothing to do with fun cameras. He may be solving problems in the packaging of bulk vitamins for dairy cattle or designing spinnerets for polyolefin hay baler twine or making x-ray processing machines run faster so that society can get more use out of its short supply of doctors.

Kodak itself really serves as a magnificently effective machine through which M.E.'s and other engineers can apply their talents against society's demands. There can be no more valid excuse for Kodak's continued existence.

The engineer's duty consists of constantly improving effectiveness. Here are five ways—each suiting a different personality makeup—to fit in:

1. Designing new products and better performance into the established ones.
2. Figuring out the best possible ways to manufacture the products.
3. Applying pure reason through mathematical tools to make the laws of physics serve human needs, not oppose them.
4. Creating the right physical tools, the right plants to house them, and the right services to keep them functioning.
5. Getting out to where the products are being used, showing the users how to get their money's worth, and bringing back word on how to do even better in the future.

If you want more specific details than that, we are very glad. Just communicate with

EASTMAN KODAK COMPANY
Business and Technical Personnel Department
Rochester, N.Y. 14650

An employer that needs mechanical, chemical, industrial, and electrical engineers for Rochester, N.Y., Kingsport, Tenn., Longview, Tex., and Columbia, S.C., and offers equal opportunity to all, choice of location, and geographical stability if desired. A policy of promotion from within has long been maintained.

"Traffic is terrible today!"

". . . Accident in the left hand lane of the Queens-Midtown access ramp. Right lanes moving slowly. Fifteen minute delay at the Brooklyn Battery Tunnel. Lincoln Tunnel backed up to the Jersey Turnpike. Extensive delays on Route 46 in the Ft. Lee area. That's the traffic picture for now, Bob."

However, technical people at GE are doing something about it. Development and design engineers are creating and improving electronic controls and propulsion systems to guide and power transit trains at 160 mph. Application engineers are developing computerized traffic control systems. Manufacturing engineers are developing production equipment and new methods to build better transportation products. And technical marketing specialists are bringing these products and systems to the marketplace by working with municipal and government agencies.

Young engineers at GE are also working on the solutions to thousands of other challenging problems—products for the home; for industry; systems for space exploration and defense. When you begin considering a career starting point, think about General Electric. For more information write for brochure ENS-P-65H, Technical Career Opportunities at General Electric. Our address is General Electric Co., Section 699-22, Schenectady, New York 12305.

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