CYBERNETICS—A Revolutionary Concept

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WHETHER we light a cigarette, drive a car, walk, talk, think, drink, manage a business, or just stand still; whatever we do; whatever results we get that appear to be purposeful must involve a cybernetic mechanism. Without the operation of cybernetic systems there would be chaos. There would be no law, no order, no stability, no apparent purpose, no—not even life.

The concepts of cybernetics are more significant and may have more far-reaching results than perhaps any other concept of our generation. These concepts are so broad, so unifying; they penetrate so deeply into every activity of living things; they underlie so many phenomena of nature from the birth and death of stars and the very origins of life itself to the smallest and most insignificant events; they unify and shed fresh light on so many fields of knowledge and research: biology, chemistry, physics, economics, psychology, management, education, engineering, art, and in fact, any activity however large or small of living things, that none of us can long afford to remain in ignorance of this development.

What, then, is this wonder cybernetics? The word itself comes directly from the Latin "gubernator," meaning governor, and this in turn from a similar Greek word meaning steersman; and cybernetics may briefly be defined as the science of communication and control in animals and machines. A simple control system operates by getting information of any deviation from some intended result and taking action to correct that deviation. It is a simple negative feedback system. It is called negative because the corrective action must obviously be opposite to the deviation, and feedback indicates that it is the resulting error or the deviation itself which is sent back as information to correct the deviation.

A thermostat is a familiar example of negative feedback; an excessive temperature is detected by a thermometer which operates a switch cutting off the current and allowing the temperature to drop again. It functions as an information and control unit which maintains an intended situation, in this instance a certain temperature.

Hierarchy of Controls

A more complex example is a rolling mill which must maintain a constant thickness of steel strip. Electronic equipment measures the thickness of the strip issuing from the mill; any variations are immediately detected and adjustments automatically made to rectify these variations. Other examples, again from engineering, are the wonderful feedback systems that prevent fading in our radio sets and almost miraculously correct the distortions introduced by the set itself. Examples of controls in automatic pilots, rockets, automated factory lines and so on are endless.

Biologists and physiologists now know that the human body contains a vast hierarchy of controls which help to maintain a constant and stable state. The American physiologist W. B. Cannon termed this condition homeostasy and many others have described the intricately interlocking feedback mechanisms which control the body temperature, salt and water content, and the chemical nervous and physical balance of the whole frame. Nervous disorders such as Parkinson's disease and ataxia are themselves examples of physiological control systems which have got out of order, and hunt, and do other things exactly paralleled by similar disorders of mechanical and electrical systems.

The whole evolutionary process itself may be regarded as one vast complex for getting results. The results that have in fact ensued are staggering; starting with some complex amino-acid molecules in the primeval seas, a colossal cybernetic process acting over aeons of time has developed man himself. Evolution is no accident; it could be more aptly described as a whole host of accidents to the unfit, and these accidents were neither planned nor were they random. There is a mechanism working here, and it may be understood in terms of cybernetics. It is obviously a highly effective mechanism for getting results. It has produced literally millions of the most extraordinary forms of life, each perfectly fitted to occupy every nook and cranny of the earth, and the mechanism is none other than the cybernetic mechanism of negative feedback.

In every generation a species produces a surplus of individuals with countless variations; the criterion for survival is fitness for the environment; useless deviations are weeded out. Thus, given the facts of heredity, every succeeding generation is, as it were, a corrected generation. This summary, of course, is oversimplified, but broadly that is how evolution is seen to work. Biologists are now working on the mechanics of the DNA molecule, found in all living cells. In the complex structure of this molecule is located not only all the information necessary to determine whether the cell is that of a cat or cabbage, a man or mouse, but also the mechanism to control and ensure that, when it multiplies, it will multiply into cells identical with itself. Sometimes, alas, controls go wrong and a local multiplication becomes a cancer. It is possible that cybernetics may have something to contribute to the cure of cancer.

In economics there are similar examples; for instance, if there is a shortage of a certain commodity the price goes up and producers are encouraged to increase production. The increased amount of the commodity and competition operate to bring the price down again.

So far only negative feedback systems or systems making for stability have been described. What would happen if the feedback were positive, that is, if any deviation fed back, not to cancel out the deviation, but to accentuate it further? Normally a steam engine governor, for example, is so arranged that when the speed rises it operates a valve to reduce the amount of steam entering the engine and the speed drops. Suppose, however, the linkage were reversed so that, instead of cutting off the steam, more was admitted. Clearly, any increase of speed letting in more steam and so further increasing the speed could only lead to racing and ultimate disaster. Conversely, any dropping of speed would slow down the engine still further till it ultimately stopped. Such a positive feedback system would therefore be unstable.

The world is full of examples of this positive or runaway kind of feedback and not only in engineering or technology. A nation arms because it feels insecure, increasing the fears of its rival which sets out to become even stronger, which in turn reinforces the worst fears of the first, and so on to an explosion. "Nothing succeeds like success" is, of course, a proverb which describes a positive feedback process. Success feeds back and encourages and stimulates to greater efforts and success. Failure and discouragement, on the other hand, produce a positive feedback in the opposite direction.

Such examples might be quoted endlessly, but perhaps enough have been offered to lend weight to the point that the study of cybernetics promises to produce concepts unifying a vast range of phenomena, in every field of knowledge and activity. It is all very interesting, and all very important, but what is there in it specifically of significance for British industry?

We in industry are concerned with getting results. Indeed, a compact definition of management might well be: the art and science of getting intended results. The next 20 years will see a revolution in management techniques. Management will become more of a science and less of an art, and cybernetics will be the key and basis of that science. It may be predicted that cybernetics will revolutionize industry, and by that is meant not merely the introduction of automation or computers which, of course, are clearly based on cybernetics, but that the whole of management will be based on concepts of cybernetics. Managers must learn to think in entirely new ways about the everyday details of their work, and it cannot but be disturbing to the man who dislikes having to learn his job anew.

Nothing can be more disturbing and difficult than changing familiar ways of thinking, and the changes forecast are by no means minor ones. By any standards they are drastic; nevertheless, we shall be forced to make these changes. Just as the industrial and scientific revolutions came and swept irresistibly along those who did not have the sense and insight to understand and go along with them; so now, the cybernetic revolution is upon us, and we cannot stand aside or run away; only the ignorant, the timid, or the lazy minded would attempt to do so.