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SOME APPLICATIONS OF AUTOMATIC CONTROL

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The field of automatic control is relatively new. To most people automatic control means some device such as a thermostat which will turn an electric current on and off. Actually a thermostat is the simplest form of controller and for many industrial processes would be unsuitable. In the short time available it will be impossible to give much information about the theories involved. However, it is hoped that those not familiar with the subject will obtain some idea of what is meant by control.

The terms instrumentation and control are very broad and will have different meanings to people working in the several fields of science. Each branch uses instruments and controllers of one sort or another. Many of these are especially designed for a given purpose, however the theory involved is identical in many cases.

The present discussion will apply only to the applications in the chemical industries, however much of the theory is applicable generally.

A controlled system consists of the following parts:

1. The process being controlled.
2. The measuring element which detects changes in the variable being measured.
3. The controller which received the signal from the measuring element and then sends a signal to the
4. Final control element which then regulates the flow of the energy to the process.

It should be pointed out that there are no automatic controls which can reason. The controller cannot react until some change in the measured variable takes place, it cannot predict a change. With manual operation on the other hand, the operator may foresee a change and start to make the correction before the change actually begins.

Due to the short time, very little can be said about the measuring methods used. In the chemical industries there are four important variables measured and controlled. These are pressure, temperature, liquid level and fluid flow. Measurement is of considerable importance, since no controller can operate properly if the measurements are not correctly made and with as little lag as possible. The lag or time delay is the most important characteristic of a measuring device that affects the quality of control. Consider a thermometer at 20°C which is placed in a bath at a temperature of 100°C. It will be found that the time temperature curve is logarithmic. The lag coefficient is defined as being the time in minutes required to reach 63.2% of the possible temperature rise. The lag coefficients of measuring instruments vary from as low as a fraction of a second to fourteen minutes. It is obvious that any device that requires a long time to detect a change will make control difficult.

The next part of the system, the controller, interprets the readings of the measuring element and produces any counter action necessary to maintain the variable at its prescribed level.

There are a number of types or modes of control in use at the present time. The simplest and cheapest is the on and off or two position control. As the name signifies the energy supply is either on or off depending upon the level of the variable. This mode of control produces a record which is cyclic in nature. Certain adjustments can be made to change the amplitude and period of the cycles but not completely eliminate them. Most thermostats are of this type.

The second mode of control is the proportional or throttling. The energy supply in this case is varied directly with the variation from the control point or the rate of energy change is proportional to the rate of change of the variable. With a properly adjusted control of this type the record produced is a straight line with no tendency toward cycling. This mode has one undesirable characteristic, in that it will not maintain the same control point for different process loads. This effect is called "droop" or "offset."

The third mode is the proportional speed or floating control. This mode supplies energy at a rate proportional to the variation from the control point. In other words the energy is changing at all times except when the variable is at the control point. With proper adjustment of the rate of energy change, this mode will not cycle.

A fourth mode of control is the rate or second derivative response. The energy change is proportional to the second derivative of the deviation or the rate of the rate of change of the deviation.

To summarize, then, the four modes discussed together with the equations defining their action are as follows:

Mode	Rate of energy change	Energy level
Two position		
Proportional	$-\frac{dP}{dt} = \frac{1}{s}\frac{d\theta}{dt}$	$-P = \frac{1}{s}(\theta - c) + K$
Proportional speed	$-\frac{dP}{dt} = f(\theta - c)$	$-P = f\ {}_{0}^{t}(\theta - c)dt + K$
Rate	$-\frac{dP}{dt} = q\frac{d^2\theta}{dt^2}$	$-P = q\frac{d\theta}{dt} + K$

Where,

P = the fraction of the total energy input
t = time in minutes
θ = the variable in fraction of the total range of the instrument
c = control point in fraction of the total range
K = integration constant
f, s, q = proportionality constants.

The two position mode is used only for cases where close control is not necessary, where cycling has no deleterious effect and for processes which are easily controlled. This mode is not suitable for more complicated processes or flow control.

Of the other three modes the proportional and proportional speed are used alone. Where control is difficult it is desirable to combine two or more of these modes into one controller. It was previously stated that the proportional mode exhibited the phenomenon called "droop." If the proportional speed mode is added to the proportional, this effect is eliminated. In the terminology of the industry, this combination is the proportional control with automatic reset or droop corrector. When there is a change in the variable the reaction produced by this combination is such that the correction follows or lags behind the variable. The amount of the lag depends upon the process characteristics and the controller settings.

The rate or second derivative control is sometimes added to the other two making a still more complicated instrument, but one which will make corrections much more rapidly than the others. In fact with this combination, the controller action leads the change in the variable, the amount depending upon the process characteristics and controller settings.

Many manufacturers produce controllers of the types described above. The mechanical means of performing the operations varies but the results are approximately the same in all cases.

Much has been published about electronic instruments in the last few years. These instruments have proved very useful for a number of reasons, two of which are as follows:

1. Greater sensitivity. Very small changes can be detected which when amplified are powerful enough to cause a controller to operate. This is perhaps the greatest advantage of the electronic devices. An example of an instrument depending upon very small changes is an extensometer. The length change is measured by the change of resistance of a small element attached to the specimen. Obviously the small change in resistance caused by the stretching must be amplified many times to be useful. The same instrument can be used for temperature measurement and can detect very small temperature changes. Several other examples could also be given.

2. There are several potentiometers on the market without the usual galvanometer. The detection of unbalance is made by an electrical system, the signal then amplified electronically and in turn

operates a balancing motor. The ordinary galvanometer must operate in an upright position and be stationary. The electronic potentiometers can operate in any position or when in motion. They were used in large numbers during the war on ships and planes where ordinary galvanometers would be useless.

Developments of the principles and applications of these instruments was hastened greatly by the war. All instrument companies were operating at top speed. In new plants constructed, the fraction of the total cost represented by instruments has increased tremendously. This was particularly true in the petroleum and synthetic rubber industries. This industry lends itself to automatic control better than many others and also is in a sufficiently good financial position to purchase large numbers of instruments.

In conclusion, the theory and applications of instrumentation have grown tremendously in the last few years and will continue to do so. The tendency in many industries is toward continuous processes which are particularly well adapted to control.

EFFECT OF CERTAIN PHYSICAL AND CHEMICAL AGENTS ON THE TREATMENT OF MOUSE LEUKEMIA*

* The study was aided by a grant from the Jane Coffin Childs Memorial Fund for Medical Research and the National Cancer Institute.

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ABSTRACT

Experimental leukemia may contribute valuable knowledge pertaining to human leukemia and related diseases. Furth, Flory, and their associates have shown mouse leukemia to be markedly similar to human leukemia. The blood picture of a high white count with numerous immature cells in the circulating blood, the development of a terminal anemia is similar to that found in man. Histological changes are practically identical to those found in the human disease and both show enlargement of spleen, liver and lymph nodes. Human leukemia runs a variable course with frequent spontaneous remissions in which the blood picture tends to become normal and clinical symptoms regress. These spontaneous remissions make the evaluation of a therapeutic agent unreliable. In the use of mouse leukemia for testing therapeutic agents, one avoids many difficulties encountered in evaluating a given treatment in the human disease. Untreated animals serve as controls and increase in sur-