Sinusoidal Flow Simulation with Pulses

E. R. SUTHERLAND and H. R. BUNGAY III

Virginia Polytechnic Institute, Blacksburg, Virginia

Sinusoidal flow is used extensively as a forcing function for frequency response analysis, but low frequencies are difficult to obtain. For our work with microbial systems, we have devised a timer which sends electrical pulses to the motor on a small pump. These pulses simulate a sine wave output and the pulse spacing is close enough that the wave distortions are negligible. Typical flow ranges are from a few milliliters to several hundred milliliters per hour, but other flows are possible with suitable pumps. The pump is a Sigmamotor Model T-8 powered by a geared motor (15 in.-pound torque). The pumping rate is changed by using different sizes of tubing or by substituting a motor of different rev./min. This pumping arrangement has given very satisfactory service for several years and is particularly suitable for pulse operation because of rapid start and almost no coasting after the pulse is terminated.

The timer is shown in Figure 1. The drum rotates continuously at 24 rev./min., and a raised spiral portion can deflect a mercury switch. At one end where the raised portion encircles the drum the switch is closed 100% of the time, and at the other end where the spiral has tapered out, the switch is always open. The percentage of time closed at other positions on the drum is proportional to the distance from the end. The mercury switch is driven back and forth across the drum in a sinusoidal fashion by an eccentric pin in a slot. The selected speed at which this pin rotates gives the period of the sine wave. This period is divided each minute into twenty-four pulses of varying duration. Thus the number of segments simulating the sine wave is a function of the period as shown in Table 1.

This shows that the timer has no upper limit on the period selected but cannot be used at higher frequencies. We have not experimented with faster drum rotation to widen the acceptable frequency range, because coasting in the motors and contacting effects from inertia in the mercury switch would lead to serious problems.

TABLE 1. NUMBER OF SEGMENTS SIMULATING A SINE WAVE

Period	No. of segments
20 min.	480
10	240
2	48
1	24
0.1	2.4

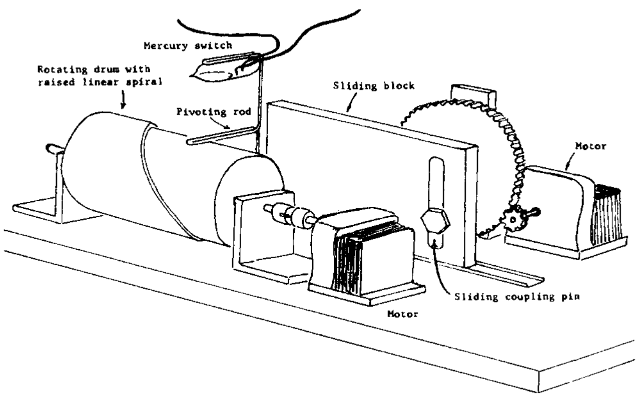

Fig. 1. Pulse generator for sine waves.

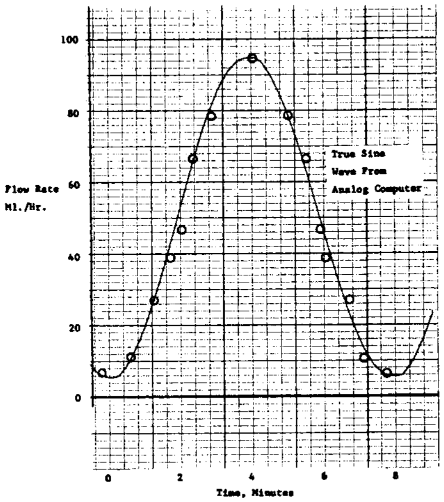

Fig. 2. Output of pump.

A typical sine wave of flow obtained with our device is shown in Figure 2. Accurate measurements were made by holding the mercury switch at fixed positions on the drum to get the flow rates; these rates were then plotted versus the time when the moving mercury switch was at these locations.

The sine waves from pulse simulation are quite satisfactory for frequency response analysis because sine waves of considerably lesser quality have often been used with success. Two mercury switches of opposite action have been used on our timer to actuate pumps on two reservoirs of different media so that the total flow is constant but the feed concentration varies sinusoidally.

ACKNOWLEDGMENT

E. G. Willard and G. H. Thomas fabricated the unit and made helpful suggestions.