CONSTANT CUTTING SPEED
In Numerically-Controlled Lathe Obtained with Analog Divider

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In lathe operations, the optimum speed of the work past the tool depends on the material and the required depth of cut per pass. If the spindle to which the work is attached rotates at constant angular speed, f_S (Figure 1), the speed of the work past the tool (cutting speed — V_T) will decrease as the tool moves inward. For a substantial range of radii (R), a chosen optimum speed of cut cannot be maintained.
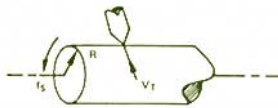

Figure 1. Relationship between cutting speed (V_T), radius (R), and spindle speed (f_S).

The relationship between cutting speed, radius, and spindle speed is a simple one.

$$V_T = 2\pi R f_S \qquad (1)$$

In numerically-controlled lathes, where the cutting radius and spindle speeds are programmable, there is an opportunity to maintain a constant cutting speed by performing the simple computation required to determine the necessary spindle speed as a function of the radius. Equation (1) can be restated:

$$f_S = \frac{V_T}{2\pi R} \qquad (2)$$

Thus, the required value of spindle speed is proportional to the ratio of cutting speed to radius.

One way of accomplishing this is shown in Figure 2, for a system in which the spindle speed is controlled by an analog voltage. Two modes of operation are available — programmed f_S and variable f_S. In the latter case, voltages derived from the digital control signals by two D/A converters are divided (Equation 2) by means of a wide-range multiplier-divider (model 433*), with a digitally-programmed scale factor. As the cutting radius changes during machining, the spindle slows down or speeds up to hold the cutting speed constant.
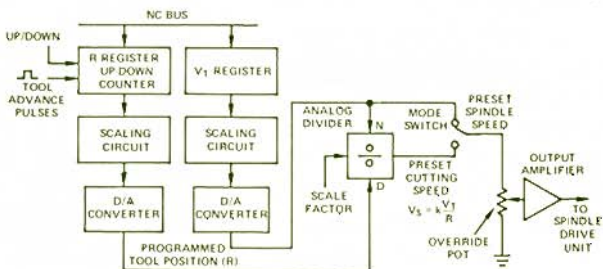
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Figure 2. Block diagram of the spindle-speed control circuit. Output amplifier provides gain changing and polarity switching.

*Use the reply card to request information on the 433 and 434 wide-range multiplier-dividers.