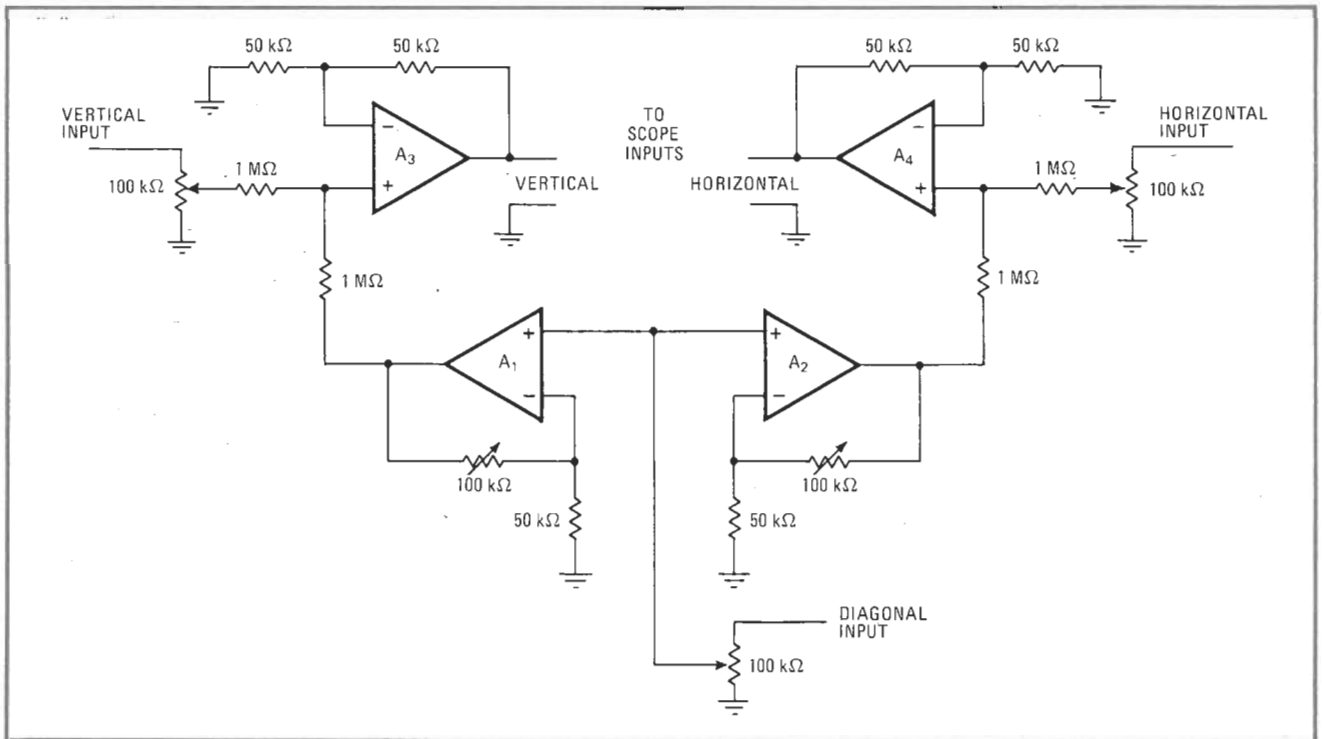


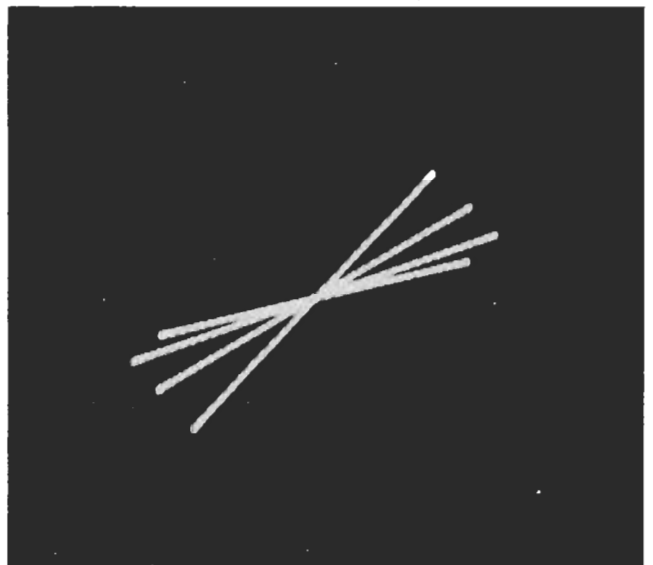
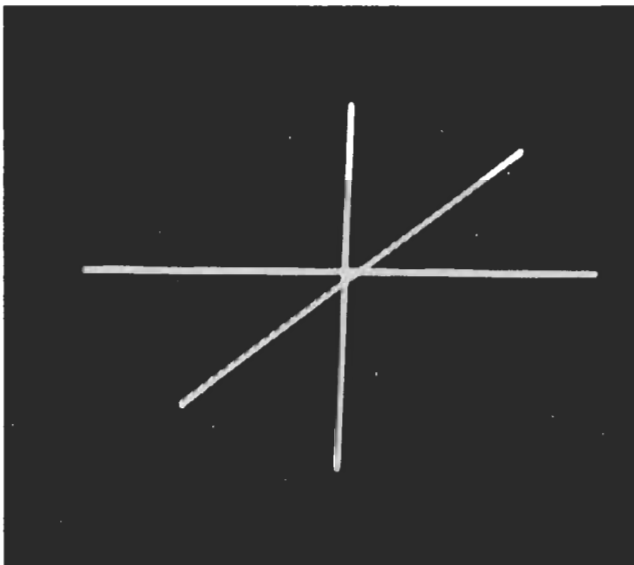
## Circuit adds diagonal axis to any scope

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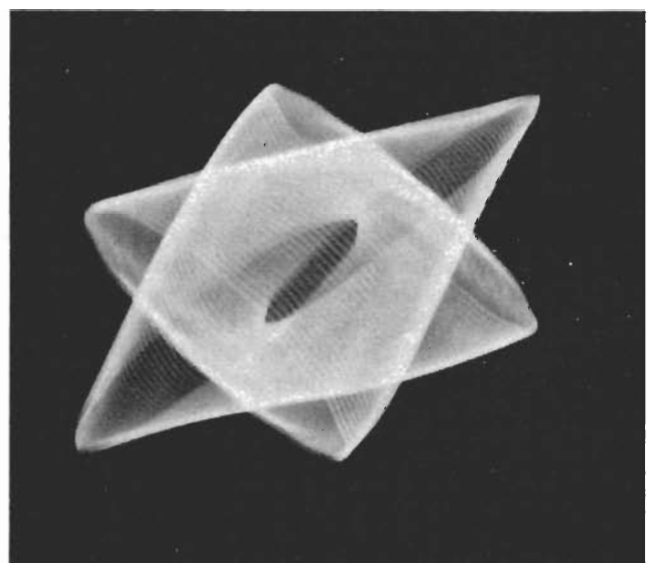
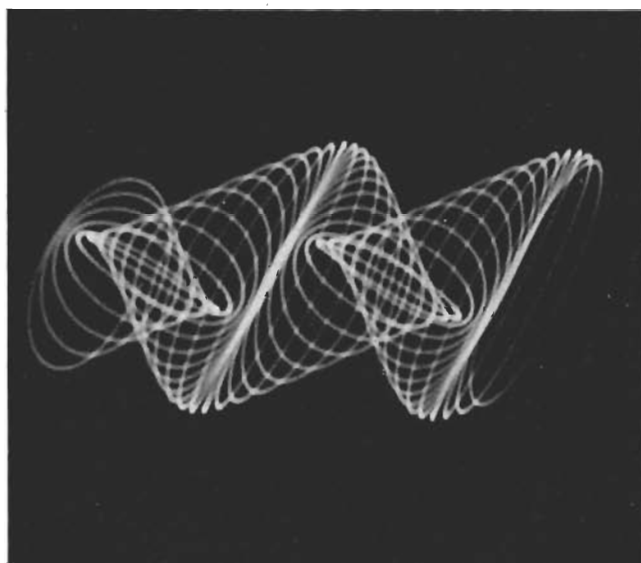
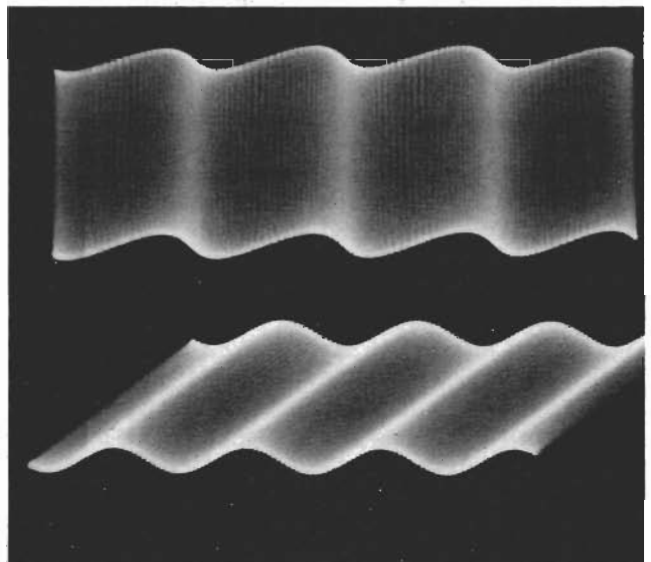
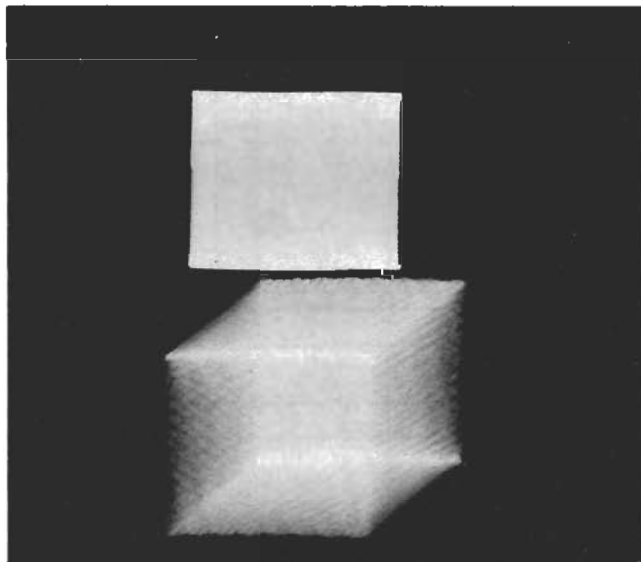
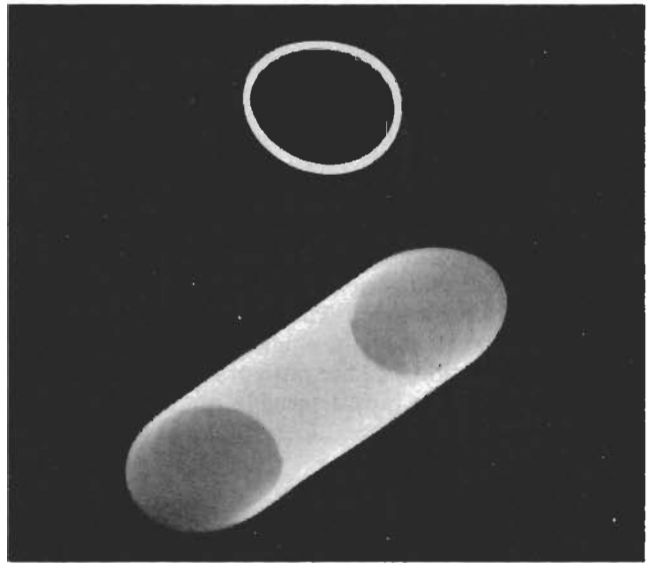
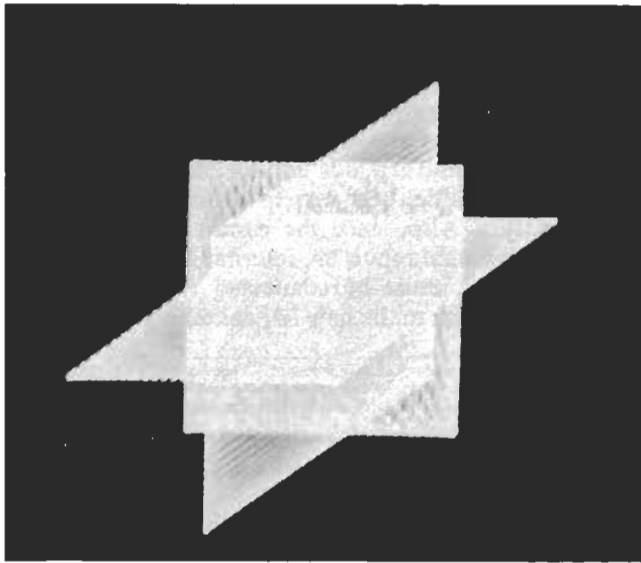
True three-axis displays can be generated in place of the usual X-Y plot on any oscilloscope with a circuit that provides a diagonal-deflection channel independent of the existing vertical and horizontal channels. The resulting X-Y-Z display can create three-dimensional effects of striking depth without any modification to the scope. Its uses include three-parameter curve tracing, three-frequency Lissajous figure studies, and



**3-d circuit.** Four operational amplifiers generate diagonal deflection to create illusion of depth on ordinary scope screen. Two op amps isolate the diagonal and the conventional inputs, and two more add these components to control the deflection.



**Three axes, various perspectives.** Triple exposure (left) shows the three deflection axes, vertical, horizontal, and diagonal. Multiple exposure (right) shows different angles of perspective, obtained by varying the ratio of the gains of the isolating amplifiers.



**3-d displays.** Triple exposure (top left) illustrates three deflection planes, X-Y, Y-Z, and X-Z. At top right is a 2-d Lissajous circle, also shown expanded into a cylinder. A square raster expanded diagonally into a cube is at center left. Two sine waves expanded vertically create wavy surfaces in X-Z and X-Y planes, respectively. At the bottom are two complex shapes produced from Lissajous figures.

three-dimensional character generation—to say nothing of many eye-catching and fascinating visual displays of all sorts.

For diagonal deflection, the diagonal input signal is applied simultaneously to both the vertical and horizontal amplifier inputs. This produces the familiar in-phase Lissajous pattern, a simple  $45^\circ$  line. Operational amplifiers  $A_1$  and  $A_2$  isolate the diagonal input from the vertical and horizontal inputs, while  $A_3$  and  $A_4$  add the diagonal signal components and the vertical and horizontal inputs respectively. The gains through  $A_1$  and  $A_2$  are adjustable, to vary the angle of the diagonal axis, which is proportional to the ratio of these gains. Adjustments on the three inputs provide noninteractive con-

trol of the sensitivities of the three channels.

The four op amps should be identical and identically compensated, especially for work at high frequencies. Otherwise, for example, if the phase-shifts through the two legs of the diagonal channel are not equal, the diagonal deflection line expands into an ellipse. Obviously a quad op amp is the best way to obtain these identical characteristics. Also, since the circuit uses the scope's external horizontal input, the internal horizontal sweep, if it is desired, must be connected from the scope's sweep-output jack to the new horizontal input.  $\square$

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