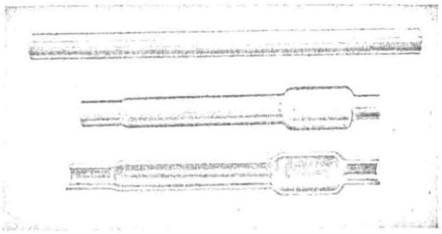

Fig. 8. Tubing expanded under high pressure.

EXPANSION OF TUBING

One of the first high-pressure forming processes to be used at Western Electric was a new method for expanding tubing. With this method it is possible to increase the diameter of sections of tubing by as much as 100 percent without simultaneously decreasing the thickness of the wall of the expanded section. Such a part is pictured in Figure 8. By contrast, by conventional methods a tube of copper can be expanded only 30 percent before fracture; furthermore, the wall thickness in the expanded section becomes quite thin.

As diagrammed in Figure 9, the device used to perform the expansion consists basically of a high-pressure cylinder the inner diameter of which corresponds to the outmost diameter of the desired part. At one end of this pressure chamber a plug shaped to receive one end of the tubing is pressed into the chamber. Between this plug and the chamber the interference fit is such that the fluid pressure within the chamber can become high enough to increase the ductility of the tubing before the chamber expands and permits fluid to escape. At the opposite end of the pressure chamber a sliding die constructed to incorporate a cavity for containing the other end of the blank is inserted. A seal prevents leakage of fluid from around this die. Finally, a high-pressure piston is mounted so as to feed fluid into one end of the tubing.

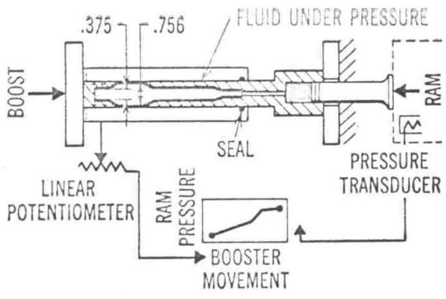

Figure 9. The tubing expansion apparatus.

In operation, the apparatus is placed into a double-ram press in which the sliding die is forced into the pressure chamber to compress the blank axially and increase the fluid pressure external to the blank. Simultaneously, the opposing ram of the press forces the high-pressure piston in to raise the fluid pressure within the tubing and so expand the tubing. The tubing is thus shortened as it is expanded, and the thickness of the walls remains unchanged.

The means of control shown in the illustration consists of a pressure transducer to monitor the internal pressure, a linear potentiometer to measure the degree of compression of the blank, and an X-Y plotter to display the operational relationship between these two variables. By operating in accordance with different curves on the plotter, one can experiment with various pressure-compression relationships.

In the production operation cam-operated pressure control is employed, and a loading pin is used to hold the part before and after forming. In addition, the chamber is maintained constantly full of fluid. With this arrangement the whole operation takes only about 20 seconds. As a result the production cost of expanding tubing by this method is about 15 times less than the cost of performing the operation by previously known methods.

DEEP DRAWING

Another important application of high-pressure metal forming is found in the drawing of shells. High pressure has been used successfully to draw deep shells from blanks of aluminum, copper, brass, and steel. With this technique it is possible to obtain a blank-to-shell-diameter ratio of as much as 4 to 1 in such a material in a single drawing operation. In addition, shells have been drawn in which the thickness of the walls have been reduced to 40 percent of the thickness of the blanks. This consideration makes it possible to draw very long shells from comparatively small blanks.

By contrast, with conventional techniques the maximum blank-to-shell-diameter ratio obtainable in a single draw is only about 2.2 to 1. Furthermore, while this ratio applies to very drawable material such as cartridge brass or mild steel, some of the more difficult materials can only be drawn slightly. In consequence, the new method has so far been shown to replace as many as four successive conventional drawings with intermediate annealings of the part. Finally, with conventional techniques the thickness of the shell wall remains the same as the thickness of the blank.

A simplified method for deep drawing under pressure is illustrated in Figure 10. As in the conventional process a draw die, a hold-down plate, and a drawing punch are provided, but they are enclosed within a high-pressure chamber. In operation, the chamber is filled with fluid, and a piston is used to raise the pressure of the fluid. The high fluid pressure serves both to increase the ductility of the blank and to assist the drawing operation. The latter effect occurs because the draw punch is made to include a shoulder so that the fluid

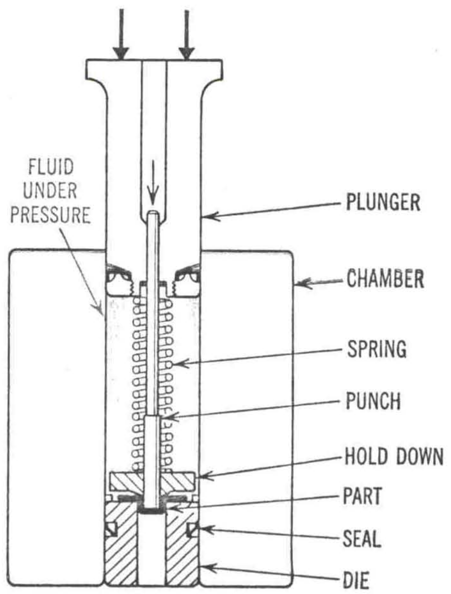

Fig. 10. Deep drawing under high pressure.