sure than under normal conditions. It would thus appear that under pressure the material follows the normal work hardening curve much farther before fracture occurs.

By elongating samples under pressure and then retesting without pressure P. W. Bridgman found that the material retained the high strength developed under pressure and still exhibited greater ductility than specimens prepulled to the same hardness without pressure.[2] This effect gives rise to the suggestion that parts made by forming under pressure would have superior quality. The real significance of this idea is economic; parts made of inexpensive materials could become equivalent to parts made of more costly materials.

In addition to the residual increase in strength, some of the historical data show that materials normally used for tools display a higher yield strength under pressure. The most noticeable such material is tungsten carbide, for which Bridgman notes an increase of about 3 to 1 in tensile strength under high pressure.[3] Since some of the useful materials for parts increase in strength to a lesser extent under the same conditions, it is evident that tool life might be increased by conducting forming operations under pressure.

Unfortunately, the fatigue strength of tool materials under pressure has not been examined; however, it would be reasonable to assume that this property is also improved. Such an improvement would be very important in cold forming operations presently characterized by expensive tooling and frequent breakage.

Under high pressure the torsional shear strength and frictional behavior of metals also change. As shown in

Material	Pressure (Psi)	True Stress at Fracture (Lbs)	Initial Area / Area of Neck
P. W. Bridgman:			
1045 Steel	Atmospheric	176,000	2.2:1
	405,000	355,000	10.0:1
1020 Steel	Atmospheric	112,000	2.5:1
	420,000	286,000	20.0:1
Ketos'	82,000	351,000	1.3:1
Tool Steel	334,000	640,000	4.1:1
Aluminum	Atmospheric	22,000	5.7:1
	410,000	63,000	20.0:1
Copper	Atmospheric	86,000	2.5:1
	410,000	100,000	20.0:1
Brass	Atmospheric	120,000	2.1:1
	390,000	194,000	3.7:1
Tungsten	Atmospheric	300,000	1.0:1
Carbide	380,000	770,000	1.0:1
A. Bobrowsky:			
Tungsten	Atmospheric	—	1.0:1
	200,000	—	2.0:1
Beryllium	Atmospheric	—	1.1:1
	390,000	—	5.0:1
Molybdenum	Atmospheric	—	3.0:1
	270,000	—	20.0:1
L. F. Vereschagin:			
Brass	Atmospheric	—	1.4:1
	450,000	—	5.2:1
Steel	Atmospheric	—	2.3:1
	450,000	—	34.0:1
H. L. D. Pugh:			
"Mild" Steel	Atmospheric	—	3.4:1
	112,000	150,000	21.0:1
Copper	Atmospheric	70,000	3.7:1
	44,800	115,000	33.0:1

Table I. Tensile tests under hydrostatic pressure.

Material	Pressure (Psi)	Shear Stress (Psi)
Indium	710,000	14,200
	142,000	3,550
Aluminum	710,000	45,440
	142,000	11,360
Copper	568,000	69,580
Nickel	710,000	123,540
	142,000	17,040
Iron	710,000	142,000
	142,000	18,460
Tungsten	710,000	163,300
	142,000	15,620
Chromium	710,000	174,660
	142,000	45,440

Table II. Shear stress under pressure (after P. W. Bridgman).

[2] P. W. Bridgman, *Large Plastic Flow and Fracture*, McGraw-Hill Book Co., New York, 1952, pp. 294-306.

[3] *Ibid.*, p. 113.