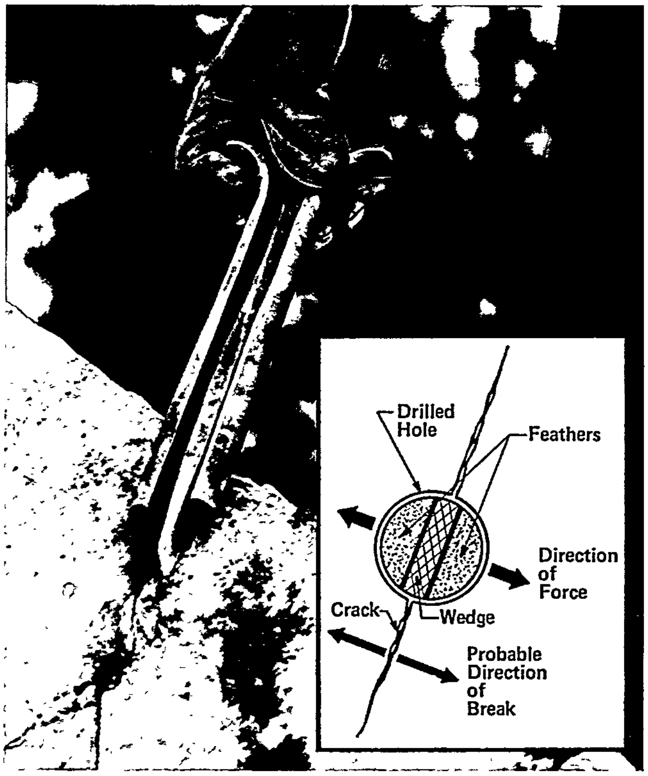
Wedges (Plugs) and Feathers

Wedges and feathers are tools designed to split rock when driven into a drilled hole or natural crack. The wedge fits in the hole between two feathers whose flat sides form a guide that prevents the wedge from jamming as it is driven into the hole. Use wedge and feathers as follows: Position the feathers in the hole so the flat sides of the wedge will be parallel to the line along which the break will occur. Drive the wedge into the slot between the feathers until the rock cracks, or until it sticks in the rock. Then tap the wedge lightly back and forth along the inside edges of the feathers until it is freed. Remove the wedge and, if necessary, begin again. Proceed slowly to allow the tools time to do their work.



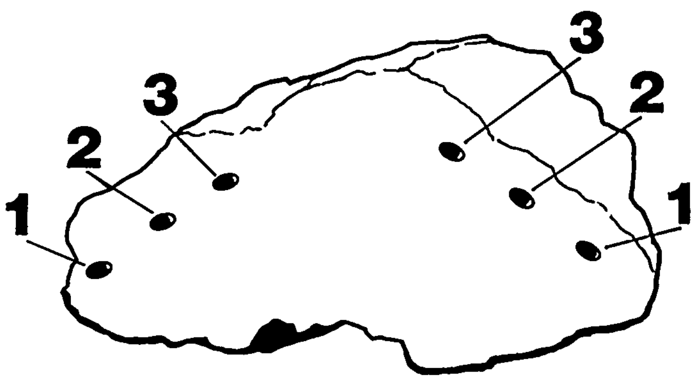
Correctly placing the wedge and feathers.

To be effective, wedges and feathers must be correctly sized. The diameter of the wedge rod and feathers at the point where the rod meets the feathers must exceed the diameter of the hole. Driving the wedge between the feathers forces them against the sides of the hole and splits the rock.

Avoid unnecessary stresses on wedges and feathers by drilling holes as straight as possible. Straight holes help keep wedges and feathers from binding or jamming in the hole.

Miscellaneous Tips

Drilling and splitting a large rock not free to move when split calls for additional care. If a hole is placed in the middle of the rock, one side may shift and jam, bend, or break the steel or the feathers and wedge. Similarly, splitting a rock that is supported only at the ends can shear tools if it breaks and slides suddenly. In instances like these, start holes from an open edge and work toward the middle. A hole drilled near the side of a large rock 18 to 24 inches from an edge will indicate how you should proceed.



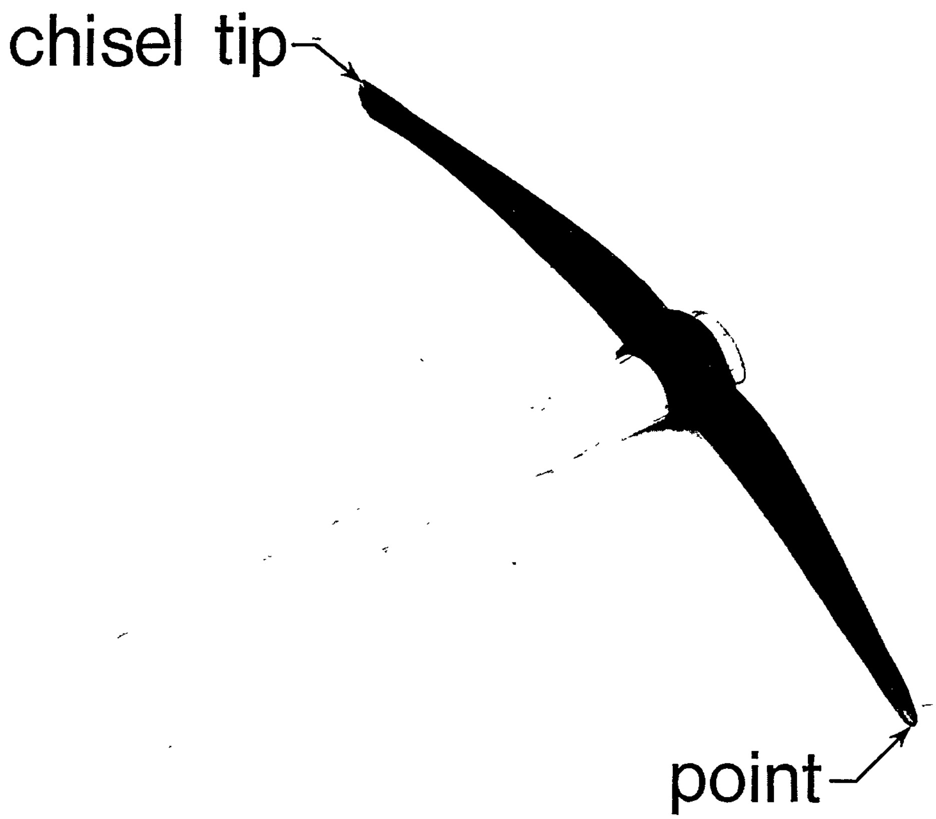
Holes drilled in these lateral locations will be less likely to jam steel or wedges and feathers than one drilled in the middle.

Picking

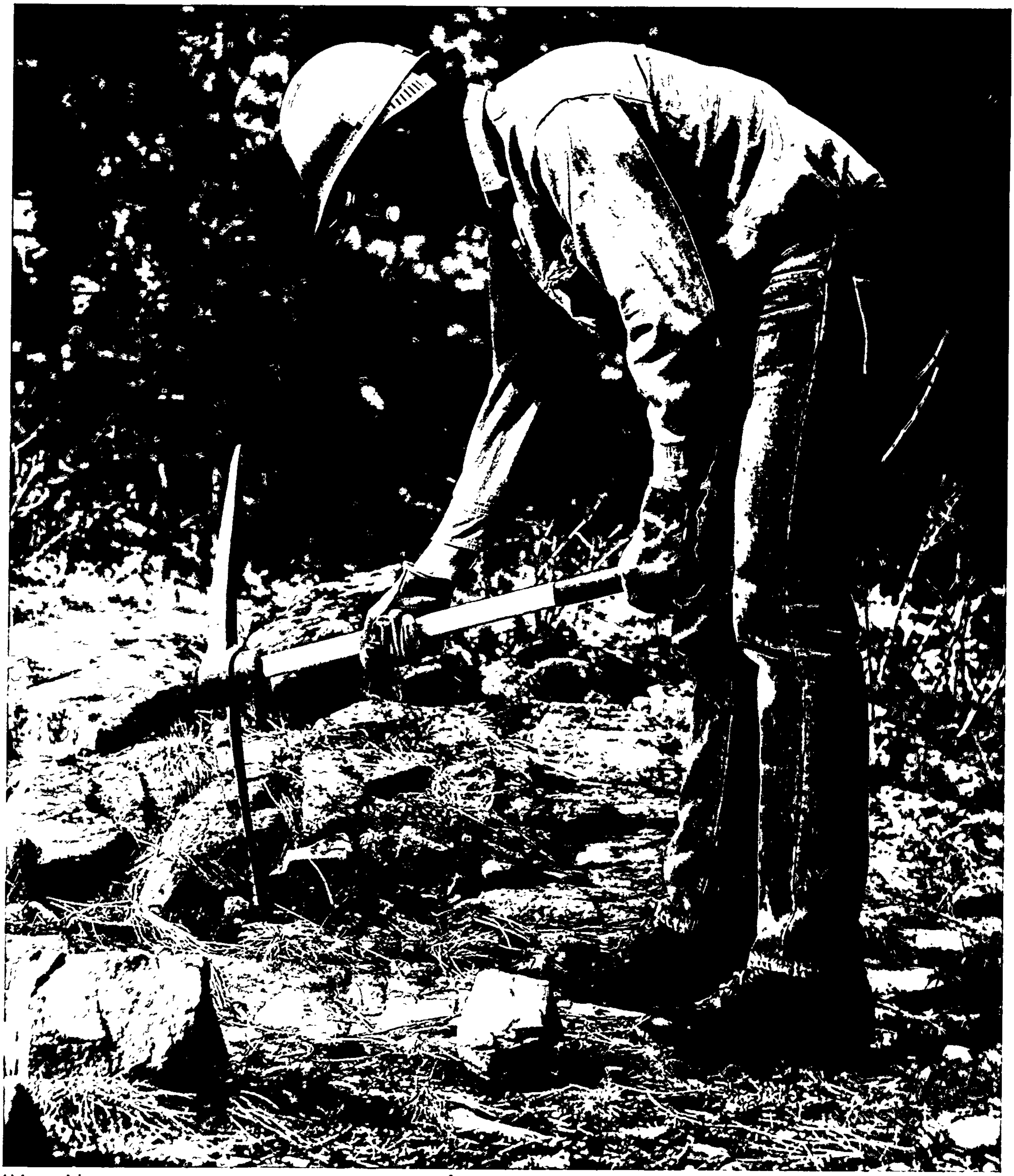
Pick heads have a pointed tip for exposing and enlarging points of natural weakness in rocks. Many times soft and medium hard rock can be broken with a pick so that no drilling is required.

When using a pick, be careful to maintain control of the head at all times. Avoid raising the pick overhead while swinging. This wastes energy needed for sustained operation, sacrifices accurate placement of the tip, and creates a safety hazard for the operator and others. The narrow heavy pick head cannot be easily controlled or directed from these heights.

Avoid using the pick as a prying tool; use crowbars instead. If picking or prying a natural seam does not split the rock, use a drilling steel or a wedge and feathers in the hole. Always wear safety glasses or goggles when picking to guard against flying chips of rock.



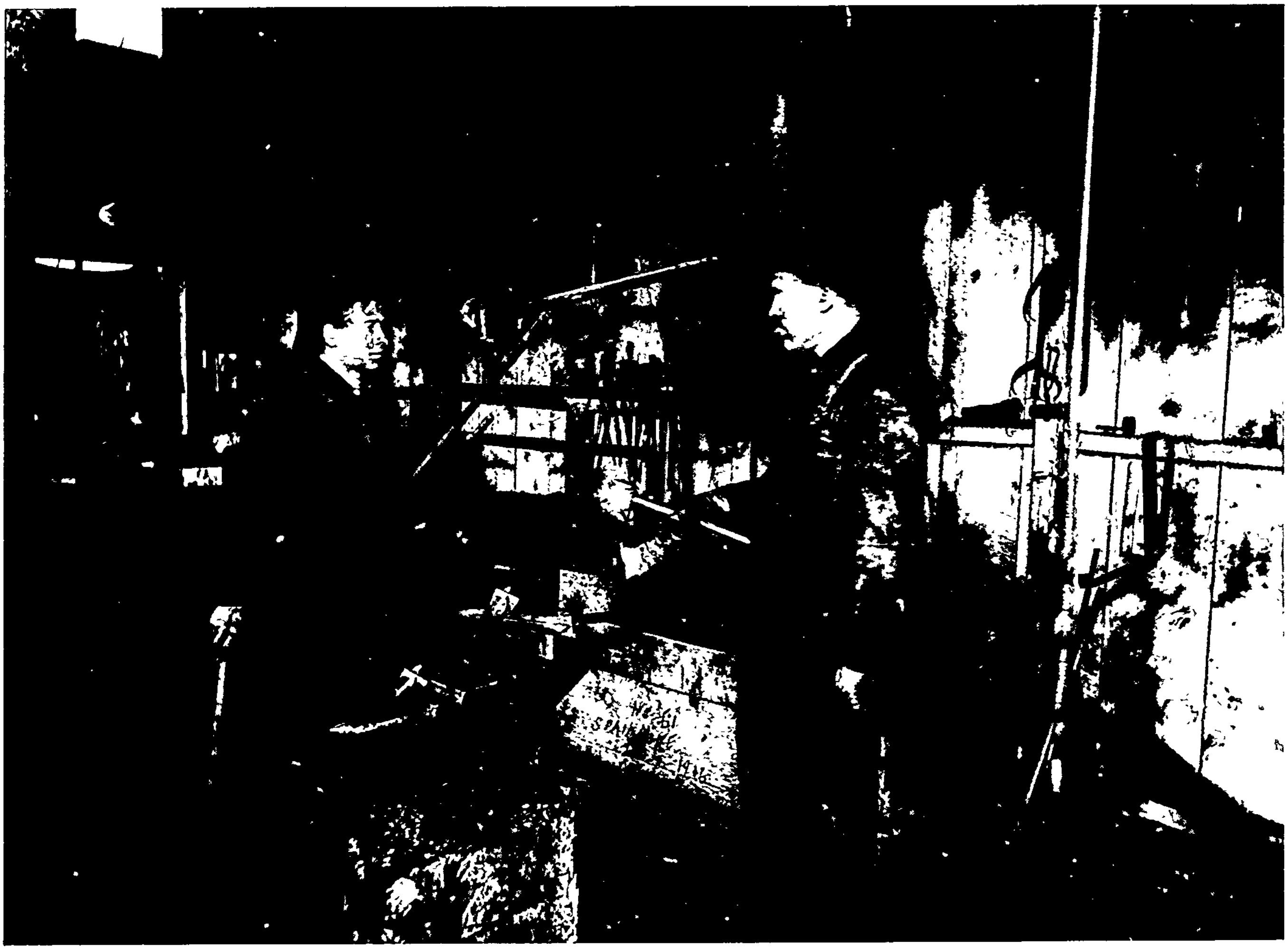
Picks are effective tools for breaking rock.



Using a pick.

Maintenance

Conscientious tool maintenance is essential to safe drilling and increases tool life. Drilling steel must be sharp and tools must be reconditioned periodically. Pick heads must be kept sharp, hammer faces smooth, and handles sturdy Wedges and feathers should be carefully protected.



Courtesy of the University of Montana Mansfield Library Archives.

Drilling Steel

Sharpening

Make sure that your steel is straight. Bent steel is nearly impossible to use effectively and a poorly placed blow could glance and cause an injury. Keep the steel sharp. Sharp steel helps you work safely and efficiently.

Use a double cut file or grinder to redress steel that is not badly worn. Maintain existing edge bevels as much as possible. In the field file the heads smooth and cutting edges sharp. Use a completed hole as a holder. Insert the steel upside down and brace it with your knee or foot. Your partner may also hold the steel while you file. Always wear gloves when sharpening or holding.

When using a grinder, remember to avoid excessive heating of the steel that could draw temper and soften the bit. Be aware that forged tools are harder on the outside than they are at their core. Careless or excessive grinding or filing can expose the core and cause premature dulling.

One worker may hold the steel while the other files.

Using a hole as a holder.

Reconditioning and Tempering

The facilities and expertise of a blacksmith will almost certainly be required to completely recondition dull drilling steel. Here is an historical account describing how a blacksmith worked:

> "Drills are sharpened, first by forging to the right shape and to give a sharp edge; this edge, however, by many smiths is not hammered sufficiently sharp, and they use either a file or a grindstone to give the required edge. The point is then heated to a glowing red and dipped in cold water for a few seconds to harden the steel; the edge is then rubbed on sand to clean it. The smith examines for the colour, and dips at a pale straw colour to make it hard, or at a dark blue, which makes it a little tougher. If, after the first cooling, there is not sufficient heat in the drill for these colours to show on the edge, it must be reheated in the fire. When the drill is dipped for tempering, it may remain in the water till cold. The exact colour at which steel has to be dipped varies with the quality of the steel, and also, no doubt, with the nature of the work, but a little practice will soon show." (Lupton, 1906).

Special variations in the temper and length of steel were sometimes required to drill particularly hard rock.

Modern hand drilling steel has similar forging requirements. In the reconditioning process it is important for the blacksmith to be able to control the hardness of steel by tempering. In general, the harder the steel, that is, the more cohesive the particles of metal, the more resistant the tool will be to wear. If the steel is made too hard, however, it may become brittle and break during use.

Standards for the hardness of tempered steel have been established that guide smiths to the correct hardness for a tool based on its usual range of applications. Hardness is measured by pressing on tempered surfaces with specific shapes under a known pressure. The amount of pressure that the tempered metal is able to withstand before an indentation is made becomes a measure of its hardness. The best known measures of hardness of tempered steel for tools are Rockwell and Brinell hardness. Rockwell hardness tests measure the indentation of a diamond cone (Rc), or a steel ball of a specified diameter (Rb), on a tempered surface. Brinell hardness tests measure only with a ball (HB) (see chart p. 26).

The steel on the tool's surface is slightly harder than the steel in the middle. This is because during the quench the particles on the surface are more radically affected; they are more cohesive than those in the middle or slightly beneath the surface. The key to tempering is to retain the desired toughness at the center of the tool. The softer core assures a strong tool, while the hard exterior provides the cutting edge or protective shield.

Complete Reconditioning
Here is a description of a modern tool reconditioning process:

Forging
1. Heat the point to a yellow color (1800 to 1900°F/982 to 1038°C), for the length necessary to forge. Be careful not to heat too far back on the steel; this is the most common cause of premature breaking after reconditioning. Do not attempt to forge below a cherry red color, (1450°F/790°C) (see chart p. 26).

2. Rework tools only to their original design.

3. After forging allow the tool to cool to room temperature.

Hardening
1. Reheat the point to a cherry red color 1½ to 2 inches back from the cutting edge, making sure to overlap the forging depth.

Quenching
1. Quench in water, or in a brine or oil solution. Maintain the quench at a temperature of 75 to 100°F/24 to 38°C, to achieve Rockwell hardness (Rc) 60 to 65, Brinell hardness (HB) 600 to 652.

Tempering
1. Withdraw the tool from the quench with sufficient heat remaining in it to draw the temper. A shade of brown or dark yellow is best.

2. Rub the point clean with emery.

3. When a light straw color appears, (430°F/222°C), complete the quench.

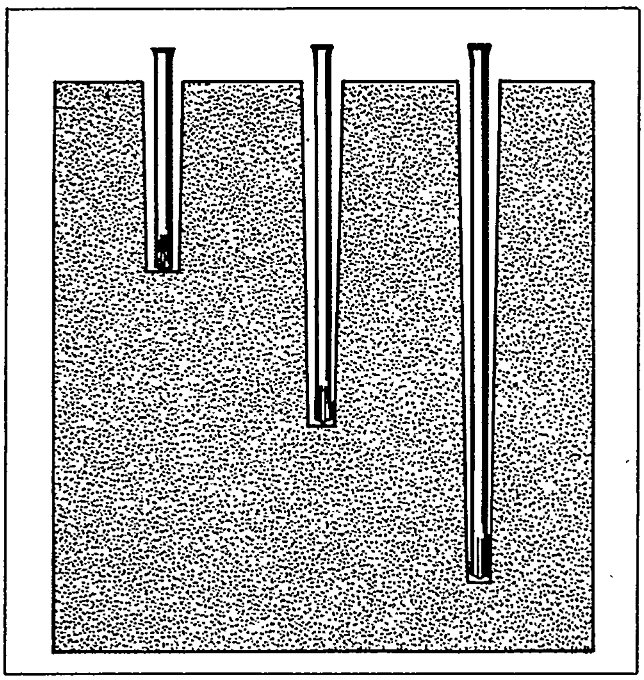
4. If drawing facilities are available, reheat to 425°F/218°C, and hold for 1 hour to achieve Rc 56 to 60, HB 555 to 600.

Miscellaneous Tips
1. Temperatures will vary among types of tool steel.

2. This operation should be undertaken only by or under the close supervision of an experienced blacksmith who knows the specific requirements of the steel he uses.

3. Wear adequate protective clothing, including eye protection and gloves, at all times.

If your drilling steel includes short 'starters' and longer 'seconds', the smith should make the cutting bits diminish slightly in width as the rods increase in length. This is necessary to prevent jamming when a new length of steel is started in the hole. A drilled hole gradually decreases in diameter as the tool wears. The bore-hole is not a true cylinder, but the frustum of an elongated cone. If the head of the steel becomes mushroomed from extended use, it should be reshaped by the blacksmith during reconditioning.



The bore-hole is not a true cylinder, but the frustum of an elongated cone.

Defective Steel and Prolonged Safe Use

Although drilling steel is designed to perform in demanding applications, few products are subjected to more stress in service. Hand-hammered percussion tools for drilling and wedging must endure the same punishment as the rock being worked, so some failures may be expected.

Defective steel is likely to fail early on due to the severe stresses from the blows of the hammer, although some break after considerable service without having been defective. To insure long life and safe use of drilling steel, avoid these common causes of premature failure:

1. Using steel for an unintended purpose. Prying with the steel, for example, will bend it and render it unsafe and ineffective.

2. Allowing steel to overheat in service. This will draw temper and cause cutting edges to soften and dull.

3. Failing to keep the steel sharp. This causes extra stress on the rod.

4. Redressing steel inadequately or improperly. Tools improperly forged and rehardened or excessively filed will dull quickly, mushroom prematurely, and break before giving a full measure of service.

Drilling Hammers

Using hammers with cracked handles, loose heads, or chipped faces is a safety hazard as well as a reflection of poor maintenance. Examine handles to insure that they are tight on heads and free of cracks. If handles have been poorly maintained or neglected, take time to repair or replace them before beginning a drilling job.

Striking faces should be smooth and evenly worn. Drilling hammers have hard tempered faces designed to strike softer drilling steel heads. The head of the steel mushrooms and the hammer face remains smooth. If a hammer face becomes pitted or chipped, however, carefully grind it smooth. Work slowly to avoid damaging the shallow temper of the face. Discard badly worn hammers. Some hammers have faces tempered soft to mushroom with use. These allow workers to safely hammer hard metals without the hammer face chipping. Mushroomed hammer heads can also be reconditioned by a blacksmith.

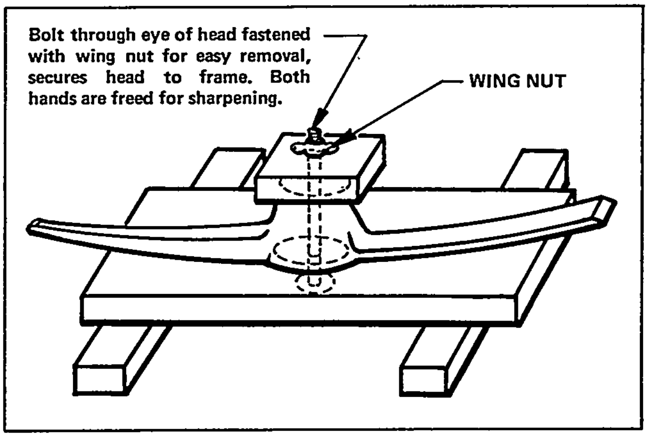
Wedges and Feathers

Wedge and feather sets should generally be treated like drilling steel. Avoid using wedges alone to break rock. Wedge tips are not tempered hard enough to start holes. Hammer wedges primarily on the heads, and avoid striking feathers as much as possible. Remember also that wedge and feathers break rock with friction and stress, so overheating can occur.

Picks

When sharpening picks grind the tips to a point 1/8-inch square. This will make a sharp, effective point that is strong enough to resist breaking. Before sharpening secure the head in a vise or special jig. Sharpen with an electric grinder or a 10-inch mill bastard file. Badly damaged picks can also be reforged by a blacksmith.

An oval-tapered eye and handle allow pick heads to tighten when swung, while remaining removable for sharpening, transporting, and handle replacement. A small screw in the handle just below the head will further fasten heads to handles.



Pick secured for sharpening without a vise.

Drilling Steel

1. Senter Tool Service, Portland, Oreg., manufactures hand drilling steel and others tools to individual specifications. The steels are generally one-piece units with a sharpened edge for drilling and a head for receiving the blow of the hammer. The cutting edges can be made in various styles, although star pattern bits are most common. The steels can also be made with removable bits if a rod of greater than 1-3/8 inches is ordered. The latter may be larger than necessary for most trail work, but detachable bits may be preferred in some situations. Senter Tool Service maintains a complete blacksmith shop, so all types of steel can be returned to them for reconditioning. Used steel that is sometimes available in second-hand stores can also be reconditioned there. In addition they will manufacture hammers to your specifications, along with a large variety of other hand tools not commonly found on the market.

2. Local blacksmith shops are usually equipped to manufacture and recondition drilling steel, and although they may not routinely fill orders for hand tools, they are often willing to help.

Courtesy of the University of Montana Mansfield Library Archives.

Drilling Hammers

General Services Administration
(branch office)

Local hardware stores

Senter Tool Service, Inc.
5413 NE Columbia Blvd.
Portland, Oreg. 97218
(503) 381-1151

Stanley Tools
(Div. of Stanley Works)
Box 1800
New Britain, Conn. 06050
(203) 225-5111

True Temper Corp.
1623 Euclid Ave.
Cleveland, Ohio 44115
(216) 969-3366

Wedge and Feather Sets

ABEMA
Box 775
Norwalk, Conn. 06856
(203) 846-2003

Atlas-Copco Corp.
610 Industrial Ave.
Wayne, N.J. 07652
(201) 696-0554

Senter Tool Service, Inc.
5413 NE Columbia Blvd.
Portland, Oreg. 97218
(503) 281-1151

Picks

Ben Meadows Co.
Box 80549
Atlanta, Chamblee, Ga. 30366
(404) 455-0907

Easco Tools, Inc.
6721 Baymeadow Dr.
Glen Burnie, Md. 21061
(301) 760-2200

Forestry Suppliers, Inc.
Box 8397
Jackson, Miss. 39204
(601) 354-3565

Sears Roebuck and Co.
(local outlet)

Union Fork and Hoe Co.
500 Dublin Ave.
Columbia, Ohio 43216
(614) 228-1791

Warren Group
(Div. of Warren Tool Corp.)
Box 68
Hiram, Ohio 44234
(216) 569-3224

Woodings-Verona Tool Works
Box 126
Verona, Pa. 15147
(412) 828-7000

DECIMAL AND MILLIMETER EQUIVALENTS

Fraction	*DECIMALS	MILLIMETERS	Fraction	DECIMALS	MILLIMETERS
1/64	0.015625	0.397	33/64	0.515625	13.097
1/32	.03125	0.794	17/32	.53125	13.494
3/64	.046875	1.191	35/64	.546875	13.891
1/16	.0625	1.588	9/16	.5625	14.288
5/64	.078125	1.984	37/64	.578125	14.684
3/32	.09375	2.381	19/32	.59375	15.081
7/64	.109375	2.778	39/64	.609375	15.478
1/8	.1250	3.175	5/8	.6250	15.875
9/64	.140625	3.572	41/64	.640625	16.272
5/32	.15625	3.969	21/32	.65625	16.669
11/64	.171875	4.366	43/64	.671875	17.066
3/16	.1875	4.763	11/16	.6875	17.463
13/64	.203125	5.159	45/64	.703125	17.859
7/32	.21875	5.556	23/32	.71875	18.256
15/64	.234375	5.953	47/64	.734375	18.653
1/4	.2500	6.350	3/4	.7500	19.050
17/64	.265625	6.747	49/64	.765625	19.447
9/32	.28125	7.144	25/32	.78125	19.844
19/64	.296875	7.541	51/64	.796875	20.241
5/16	.3125	7.938	13/16	.8125	20.638
21/64	.328125	8.334	53/64	.828125	21.034
11/32	.34375	8.731	27/32	.84375	21.431
23/64	.359375	9.128	55/64	.859375	21.828
3/8	.3750	9.525	7/8	.8750	22.225
25/64	.390625	9.922	57/64	.890625	22.622
13/32	.40625	10.319	29/32	.90625	23.019
27/64	.421875	10.716	59/64	.921875	23.416
7/16	.4375	11.113	15/16	.9375	23.813
29/64	.453125	11.509	61/64	.953125	24.209
15/32	.46875	11.906	31/32	.96875	24.606
31/64	.484375	12.303	63/64	.984375	25.003
1/2	.5000	12.700	1	1.000	25.400

1 mm = .03937"

.001" = .0254 mm

MM	INCHES	MM	INCHES
.1	.0039	46	1.8110
.2	.0079	47	1.8504
.3	.0118	48	1.8898
.4	.0157	49	1.9291
.5	.0197	50	1.9685
.6	.0236	51	2.0079
.7	.0276	52	2.0472
.8	.0315	53	2.0866
.9	.0354	54	2.1260
1	.0394	55	2.1654
2	.0787	56	2.2047
3	.1181	57	2.2441
4	.1575	58	2.2835
5	.1969	59	2.3228
6	.2362	60	2.3622
7	.2756	61	2.4016
8	.3150	62	2.4409
9	.3543	63	2.4803
10	.3937	64	2.5197
11	.4331	65	2.5591
12	.4724	66	2.5984
13	.5118	67	2.6378
14	.5512	68	2.6772
15	.5906	69	2.7165
16	.6299	70	2.7559
17	.6693	71	2.7953
18	.7087	72	2.8346
19	.7480	73	2.8740
20	.7874	74	2.9134
21	.8268	75	2.9528
22	.8661	76	2.9921
23	.9055	77	3 0315
24	.9449	78	3.0709
25	.9843	79	3.1102
26	1.0236	80	3.1496
27	1.0630	81	3.1890
28	1.1024	82	3.2283
29	1.1417	83	3.2677
30	1.1811	84	3.3071
31	1.2205	85	3.3465
32	1.2598	86	3.3858
33	1.2992	87	3.4252
34	1.3386	88	3.4646
35	1.3780	89	3.5039
36	1.4173	90	3.5433
37	1.4567	91	3.5827
38	1.4961	92	3.6220
39	1.5354	93	3.6614
40	1.5748	94	3.7008
41	1.6142	95	3.7402
42	1.6535	96	3.7795
43	1.6929	97	3.8189
44	1.7323	98	3.8583
45	1.7717	99	3.8976
		100	3.9370

METRIC CONVERSION CHART

Symbol	When You Know	Multiply By	To Find	Symbol
in.	inches	25.4	millimeters	mm.
mm.	millimeters	.039	inches	in.
in.	inches	2.54	centimeters	cm.
cm.	centimeters	.394	inches	in.
ft.	feet	30.48	centimeters	cm.
cm.	centimeters	.033	feet	ft.
ft.	feet	.305	meters	m.
m.	meters	3.281	feet	ft.
yd.	yards	.914	meters	m.
m.	meters	1.094	yards	yd.
oz.	ounces	28.35	grams	g.
g.	grams	.035	ounces	oz.
lb.	pounds	.454	kilograms	kg.
kg.	kilograms	2.205	pounds	lb.

INCANDESCENT COLORS AND TEMPERATURES

COLOR	°F	°C
Black Red	990	533
Dark Blood Red	1050	565
Dark Cherry Red	1175	634
Medium Cherry Red	1250	676
Full Cherry Red	1375	745
Light Cherry	1550	843
Salmon	1650	899
Light Salmon	1725	940
Yellow	1825	995
Light Yellow	1975	1078
White	2220	1203

COLORS OF TEMPERING HEATS

COLOR	°F	°C
Light Straw	430	222
Straw	450	232
Dark Straw	470	244
Yellow Brown	490	255
Dark Brown	510	265
Brown Purple	520	271
Dark Purple	530	277
Bright Blue	550	288
Full Blue	560	293
Dark Blue	600	316

HARDNESS TESTING CONVERSION TABLE

Rockwell C 120 Cone 150 Kg	Brinell 3000 Kg 10MM Ball	Rockwell C 120 Cone 150 Kg	Brinell 3000 Kg 10 MM Ball
	156	32	302
	159	33	311
	163	34	321
	166	35	332
	170	36	340
	174	37	351
	179	39	364
	183	40	375
	187	41	387
	192	43	402
10	196	44	418
12	202	45	430
14	207	46	444
17	212	48	460
19	217	49	477
21	223	50	495
22	228	52	512
23	235	54	532
24	241	56	555
25	248	58	578
26	255	60	600
27	262	62	627
28	269	65	652
29	277	66	683
30	293	68	744
31	293	68	744

Bibliography

Mining Books

Foster, C. LeNeve. *A Textbook of Ore and Stone Mining* (Charles Griffing Co., Ltd.) 1901.

Ihlseng, M.C. *A Manual of Mining* (John Wiley and Sons, New York) 1901.

Lupton, Arnold. *Mining* (Longman's, Greene, & Co., London) 1906.

Young, George. *Elements of Mining* (McGraw-Hill, Inc., New York) 1946.

Young, Otis E. *Black Powder and Hand Steel* (University of Oklahoma Press, Norman, Oklahoma) 1975.

Young, Otis E. *Western Mining* (University of Oklahoma Press, Norman, Oklahoma) 1970.

Mining Handbooks

Atlas Copco Company. *Rock Drilling Manuals.* V.I "Theory and Technique" and V.II "Drill Steel Applications" (Atlas Copco Co., Wayne, N.J.) 1979.

Lock, C.G. Warnford. *Miner's Pocket-Book*. (Spon and Chamberlin, London and New York) 1896.

Von Bernewitz, M.W. *Handbook for Prospectors and Operators of Small Mines.* (McGraw-Hill, Inc., London and New York) 1943.

Trail Manuals that Reference Rock Work

Arthur, Guy B. *Construction of Trails* (CCC Project Training 7, Feb. 1937). (U.S. Dept. of Interior, Washington, D.C.)

Proudman, Robert D. *AMC Guide to Trail Building and Maintenance* (Appalachian Mountain Club, Pinkham Notch Camp, N.H.) 1977.

USDA-Forest Service. *Trail Construction on the National Forests 1915* (Washington, D.C.).

USDA-Forest Service. *Trail Construction on the National Forests 1923* (Washington, D.C.).

*U.S. GOVERNMENT PRINTING OFFICE 1993-0-790-259/60009