Water Jet Machining

Synopsis

- Introduction
- Principle
- Equipment
- Process parameters
- Advantages
- Limitations
- Applications

Introduction - 1

- Type of Energy: Mechanical
- Mechanism of material removal: Erosion
- Transfer media: High pressure water
- Energy source: Hydraulic pressure
- Also called as hydrodynamic machining
- Uses a high velocity stream of water as a cutting tool
- Process is limited to the cutting of nonmetallic materials when the jet stream consists solely of water

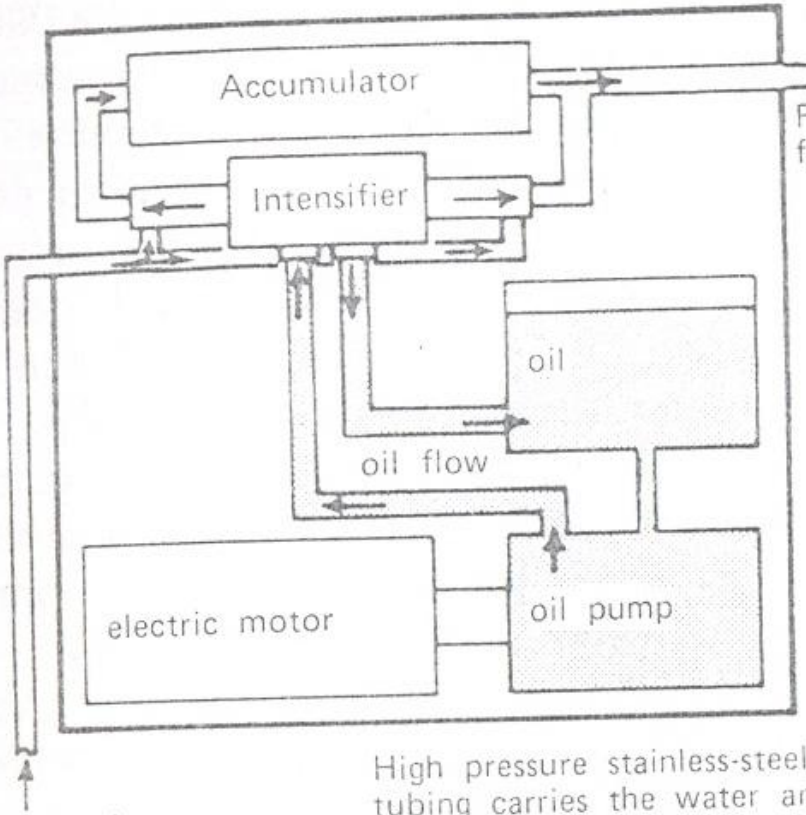
Introduction - 2

- Primarily used to cut and slit porous nonmetals such as wood, paper, leather and foam
- Variations are also available for performing wire stripping and deburring
- Principle first observed in the early 1900
- However, no significant efforts were made to apply this technology until the 1960s (patented by Norman Franz)

Working principle

- Removes material through the erosion effects of a high velocity, small diameter jet of water
- A collimated jet of water exists a specially shaped nozzle at velocities of 900m/sec
- The tight water jet core provides the cutting action
- This cutting action can be maintained through soft solids that are up to 250mm thick

THE ACCUMULATOR smooths the flow to maintain pressure within ± 5%.



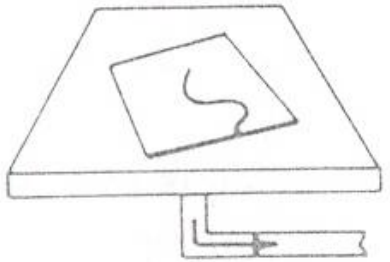
High pressure stainless-steel tubing carries the water any required distance to the cutting station

Flexible arm can be used to provide free movement of the nozzle.

The on--off valve starts and stops the cutting action

- Manual control
- Automatic control

The Nozzle



to drain or recycle

Equipment - 1

- Major components of a WJM system are:
- Hydraulic unit
- Intensifier
- Accumulator
- Filters
- Water transmission lines
- On/off valve
- Waterjet nozzles
- Waterjet catchers
- Fluid additives

Equipment - 2

- Hydraulic unit – consists of an electrically driven, variable-displacement, pressure-compensated hydraulic pump. Typical hydraulic pressures are adjustable to about 20MPa
- Intensifier – used to increase the water pressure up to 380MPa – pressure increase is determined by the ratio of the working areas of the two cylinders

WJM high pressure oil intensifier construction

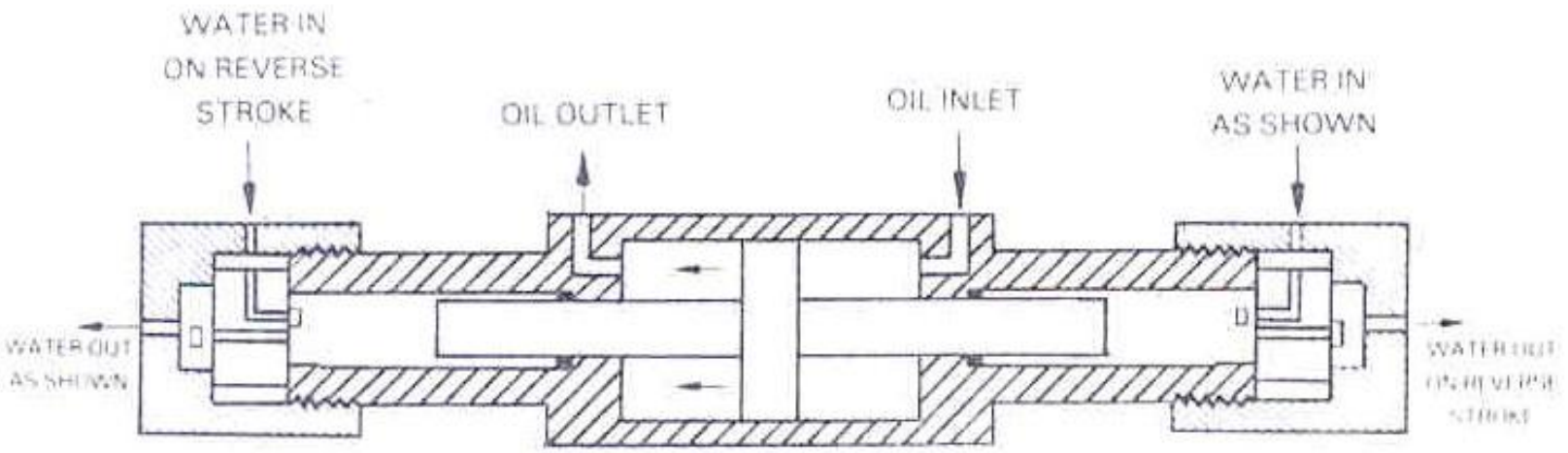
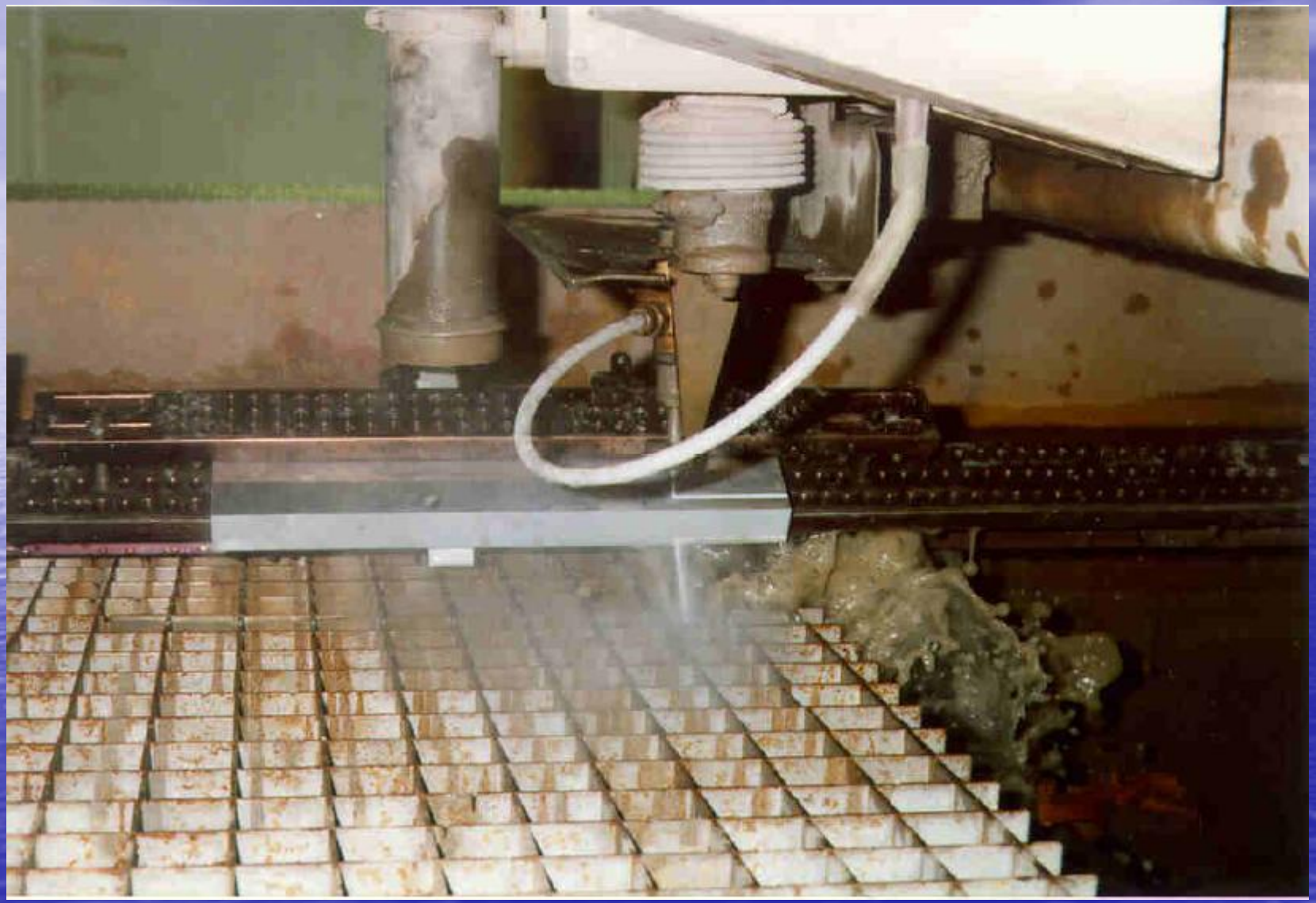


Figure 3.3 The WJM high-pressure oil intensifier constuction (Source: courtesy, Flow Systems, Inc., Kent, Wash.).

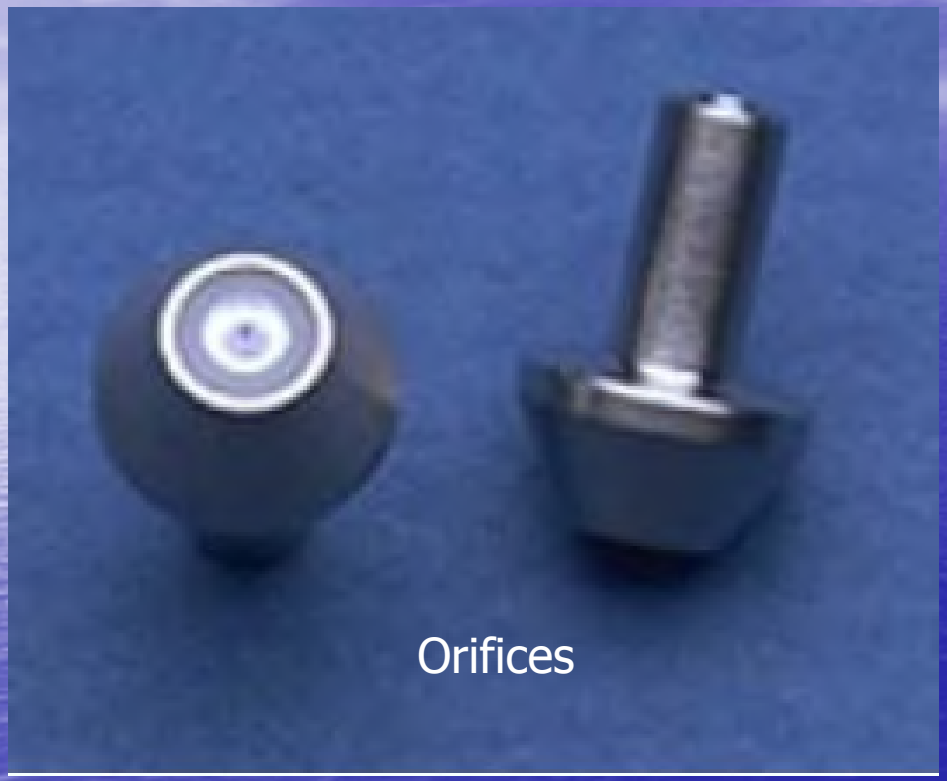
Equipment - 3

- Accumulator – also called as shock attenuator, is plumbed in parallel with the high-pressure output of the intensifier – added to smooth the pressure spikes (pressure variations from water compression can be reduced to ± 2.5%) that occur at the reversal of the reciprocating stroke of the intensifier
- Filters – they protect the nozzle orifice from possible damage by foreign material – mechanically filtered to 0.45 μm
- Water transmission lines – consists of flexible hose, hard tubing, swivels, and flex joints
- Flexible hosing capable of operating at 380MPa is available and greatly simplifies plumbing

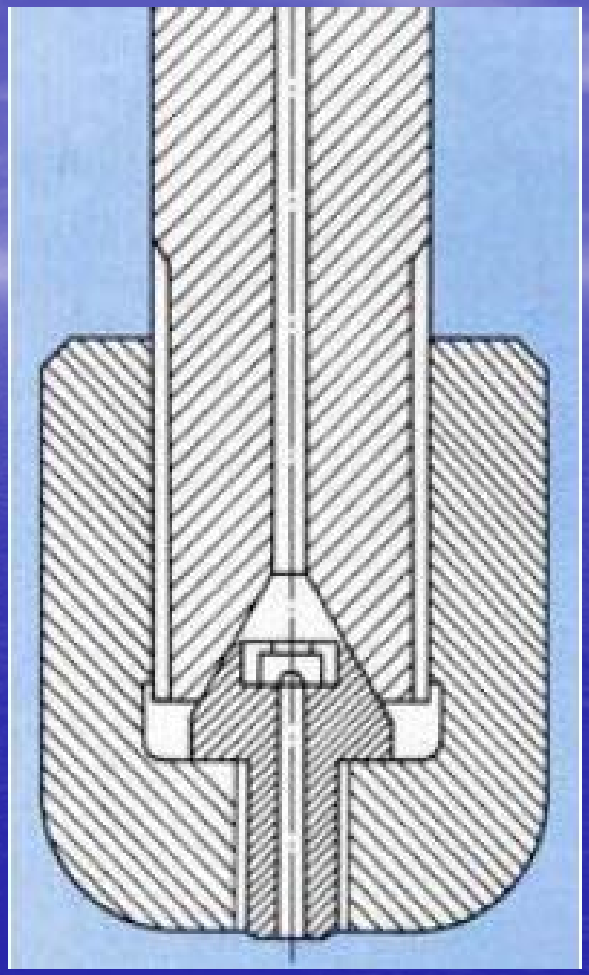


Equipment - 4

- If the hosing cannot operate at the desired water pressure, then hard tubing, swivels, and flex joints must be used
- On/off valve – two position rapid acting valve used to turn the jet stream on or off
- Waterjet nozzles – by using properly designed nozzles, a coherent water jet could be obtained
- Nozzle hole diameters typically range from 0.07 to 0.5mm and some times as large as 1.0mm – larger diameter nozzles are not used because of the prohibitively large size of the pump motor
- Material used most often for the nozzle orifice is synthetic sapphire because it is easily machinable and is resistant to wear



Orifices



Nozzle

Equipment - 5

- Recently, sapphire orifices have been replaced by diamond orifices whose life is ten times more. However, the cost of a diamond orifice is seven to ten times that of sapphire orifice
- Most common mechanism for failure of nozzle is either chipping from dirt particles in the water or constriction from mineral deposits
- Catchers – purpose is to minimize the exposed length of the jet for safety purposes and to minimize the process noise
- Tube or slot type catchers are used

Equipment - 6

- The most common type of catcher is the tube type – consists of a 300-600mm long tube that is attached to a draining hose – the length of the tube is sufficient to allow the water jet to break up completely before it reaches the bottom of the tube

Process parameters - 1

- Four parameters control the results achieved with WJM – pressure, nozzle diameter, traverse rate and the stand off distance, all define the process
- Because there is little change in the shape or diameter of the jet within 25mm of the nozzle, the standoff distance can be considered a fixed parameter
- Pressure, nozzle dia and traverse rate are varied, depending upon the material and the thickness being cut

Process parameters - 2

- In general as the power of the water jet is increased, the ability to cut faster or to cut thicker materials is also increased – this is accomplished by increasing the pressure, increasing the nozzle dia or decreasing the traverse rate

Advantages - 1

- No tool resharpening costs
- Minimum kerfwidth
- Easily automated
- Omnidirectional cutting
- Dust-free process
- High cutting rates
- Absence of heat-affected zone
- Predrilling is not required when shape cutting
- Reduction or elimination of air-borne dust due to cutting

Advantages - 2

- Capable of cutting a variety of materials without a substantial change in system components
- Multilayer cutting while maintaining quality of cut for all layers
- Deburring – to remove burrs from nonferrous parts – areas that normally would be difficult to access, such as in narrow openings, blind holes, and line of sight internal cavities

Limitations

- Equipment is moderately expensive
- Not well-suited for hard, nonporous materials
- Brittle materials may crack
- Contaminated water must be treated before disposal
- Noise and high pressure require safety considerations

Applications - 1

- Cutting of printed circuit boards
- Cutting of board materials
- Cutting of light weight fiber reinforced plastics
- Wire stripping
- Cross cutting
- Cutting foods
- Cutting web materials
- Cutting asbestos

Mechanically slit corrugated cardboard Vs WJM slit material

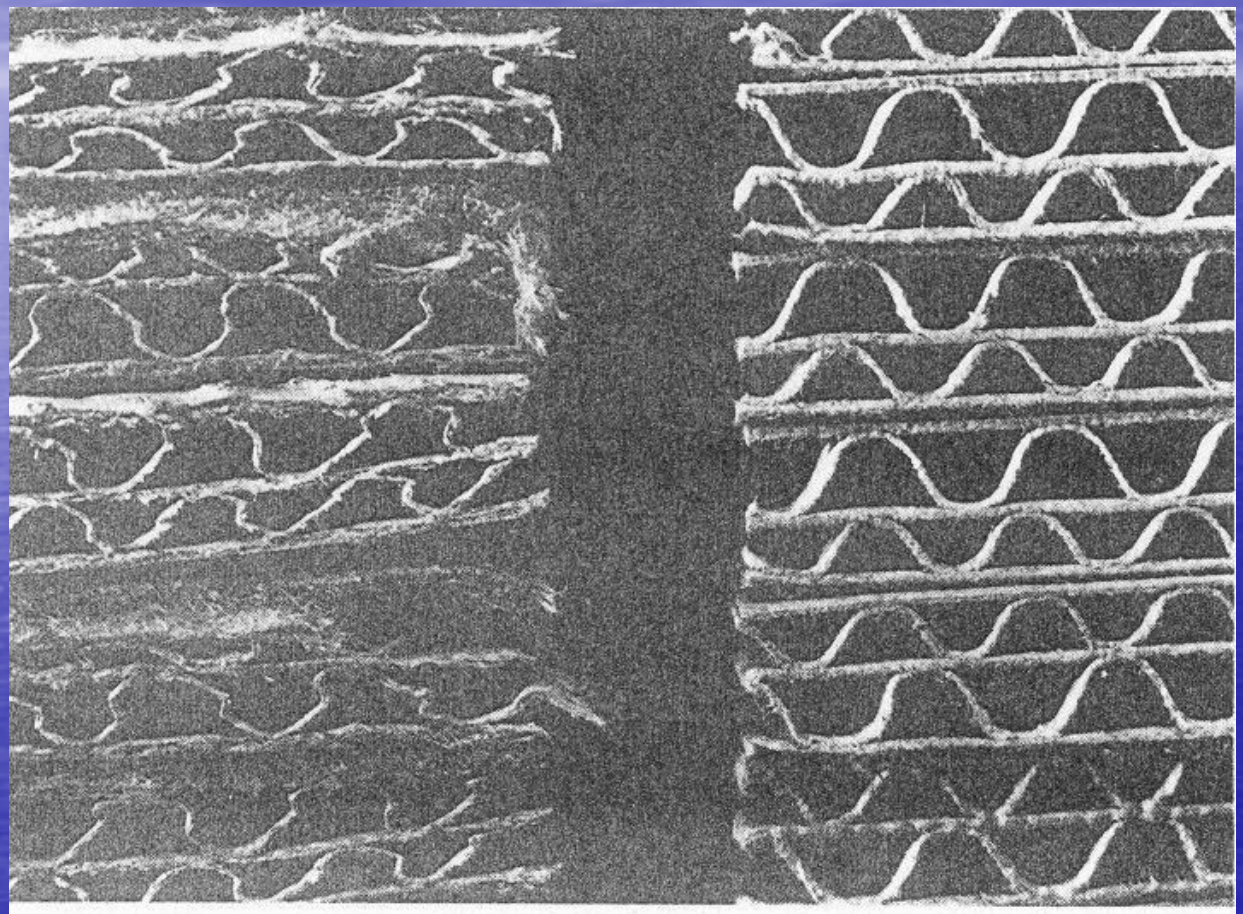


Figure 3.13 Mechanically slit corrugated cardboard is shown on the left, WJM-slit material is shown on the right (Source: courtesy, Flow System, Inc., Kent, Wash.).

WJM stripped electrical cable

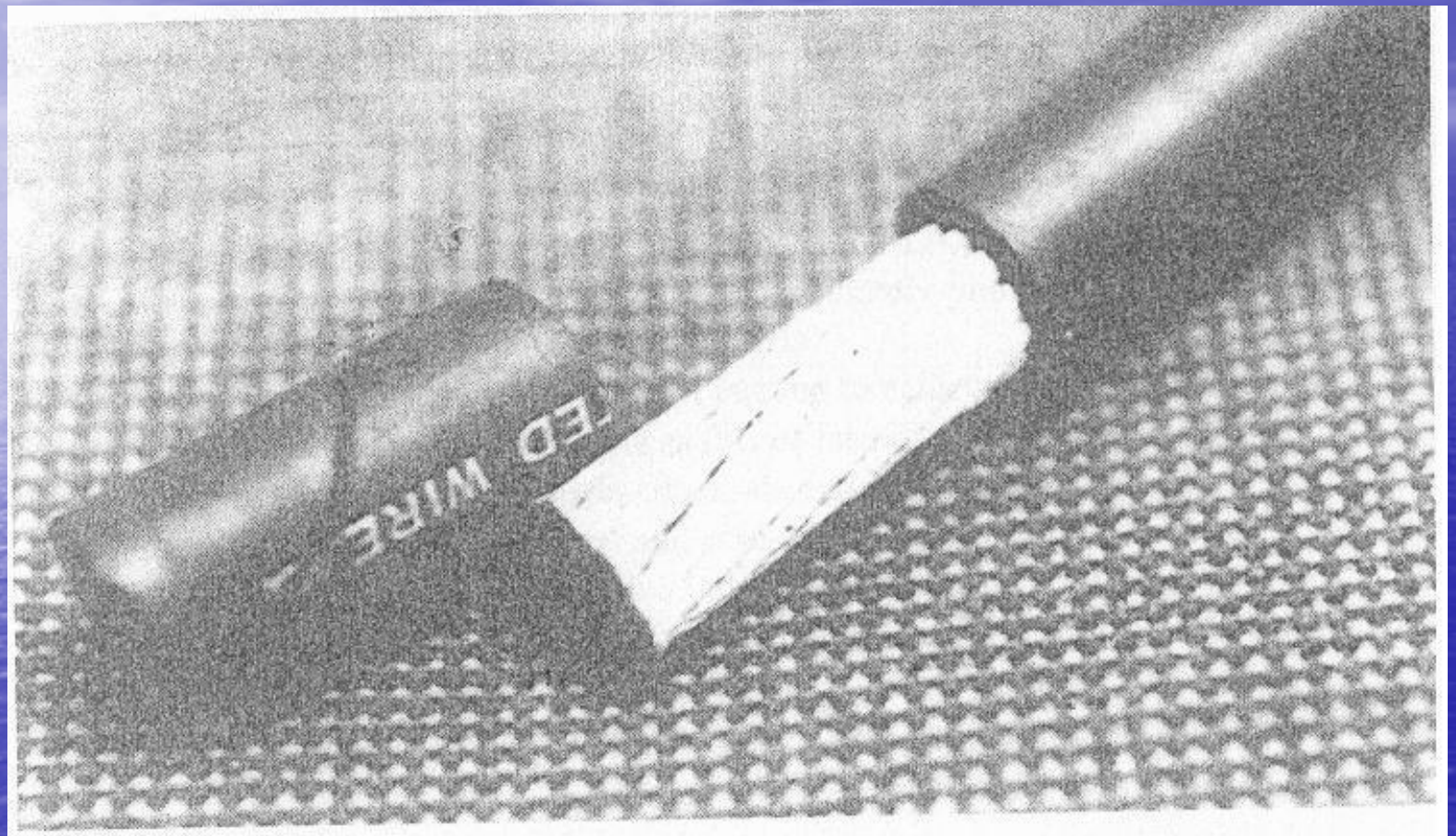


Figure 3.10 A WJM-stripped electrical cable (Source: courtesy, Flow Systems, Inc., Kent, Wash.).

WJM cut carbide grit safety walks

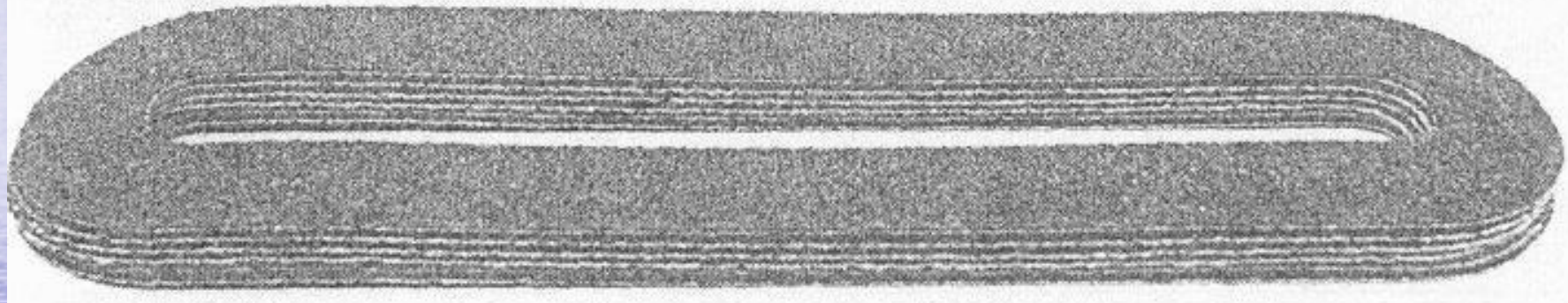


Figure 3.12 WJM-cut carbide grit safety walks (Source: Martin, 1980).


Cake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