Electrochemical Grinding (ECG)

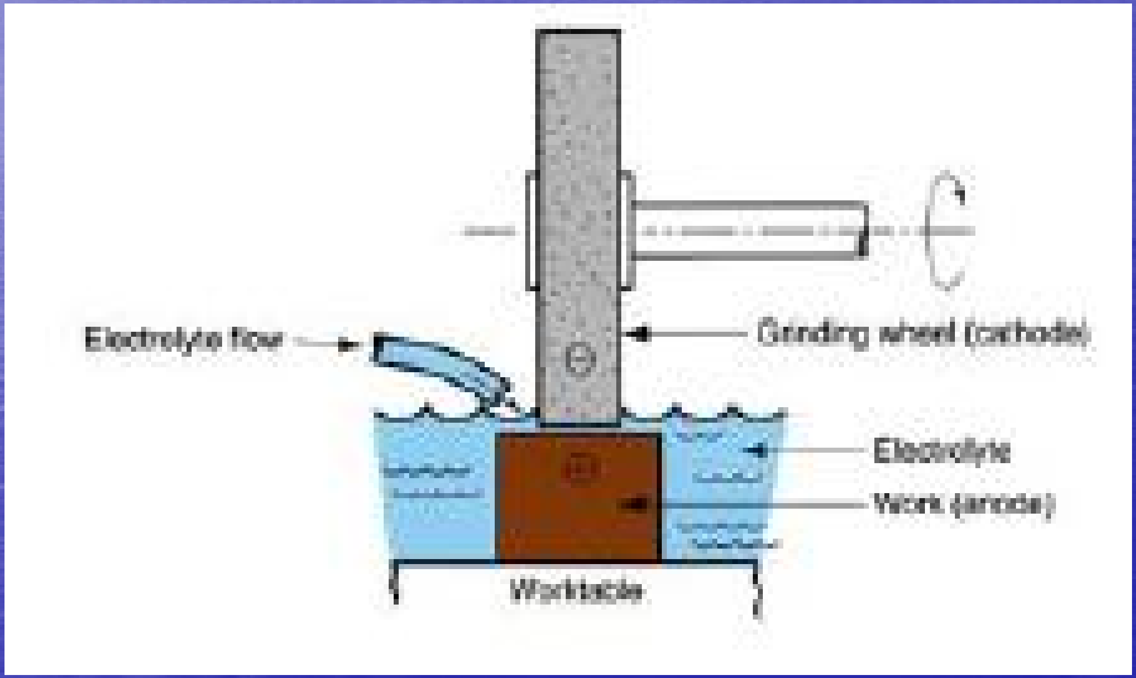
Synopsis

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

Introduction

- ECG also called electrolytic grinding is similar to ECM, except that the cathode is an electrically conductive abrasive grinding wheel instead of a tool shaped like the contour to be machined
- Used primarily to machine difficult to cut alloys such as stainless steel, Hastelloy, Inconel, Monel, Waspally and tungsten carbide, heat treated workpeices, fragile or therm-sensitive parts, or parts for which stress-free and burr-free results are required
- Process introduced in the early 1950s evolving from developments in the USSR on EDM
- ECG removes metal by a combination of electrochemical (responsible for 90% of material removal) and grinding actions
- The grinding action removes the buildup of oxide film on the surface of the workpiece
- Less power is needed for ECG than for ECM since the machining area is smaller and the abrasive in the wheel is removing the oxide film – current ranges from 5 to 1000A are most common, with a voltage of 3 to 15V over an electrolyte gap of approximately 0.25mm or less and wheel speeds of 1100 to 1800m/min
- Many similarities between ECG and conventional grinding make this one of the easiest ECM based processes to both understand and implement – grinding wheel closely resemble their conventional counterparts with the exception that ECG wheels use an electrically conductive abrasive bonding agent; electrolyte is introduced to the work area in the same manner that coolant is introduced in conventional grinding

Special form of ECM in which a grinding wheel with conductive bond material is used to augment anodic dissolution of metal part surface



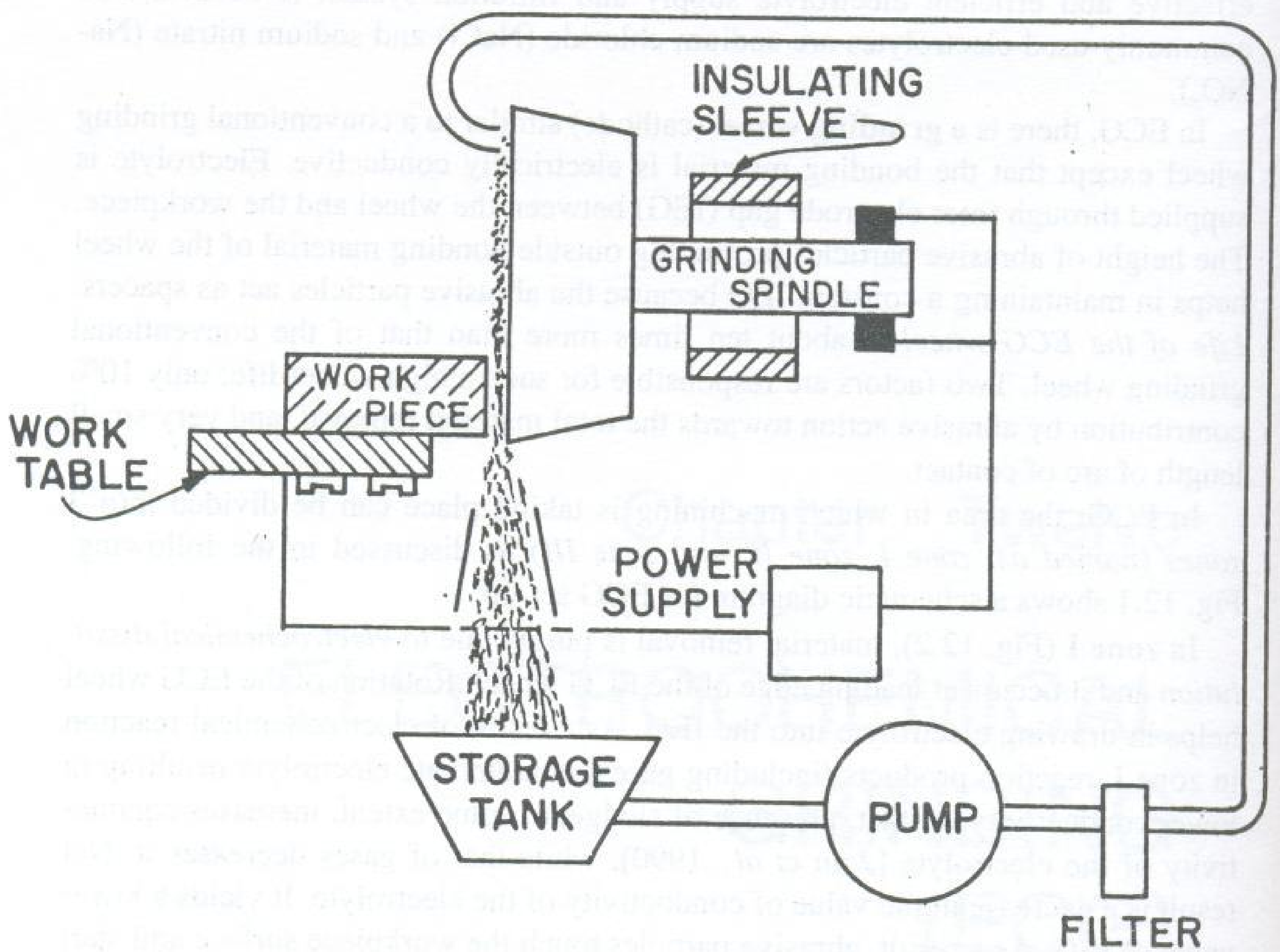
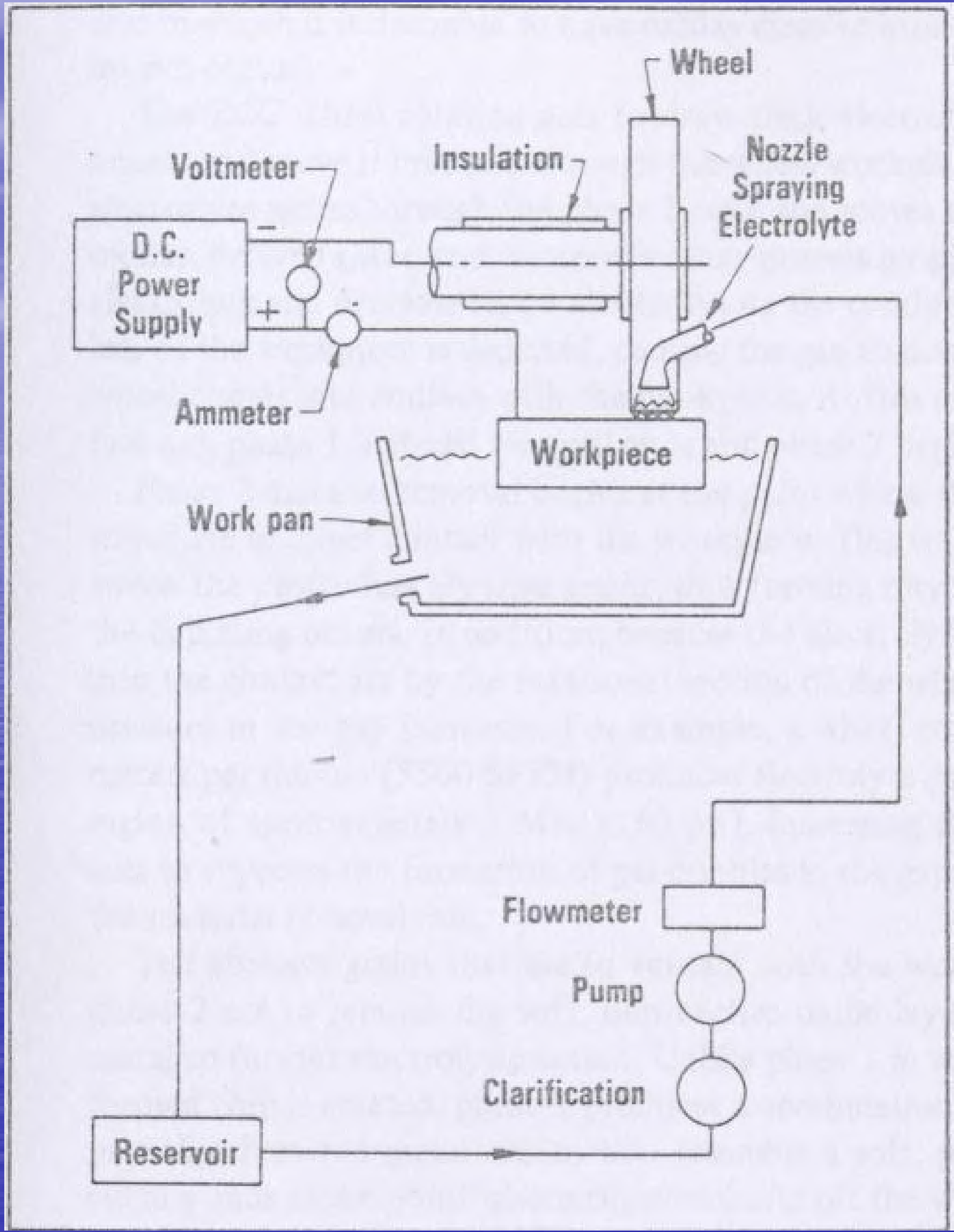
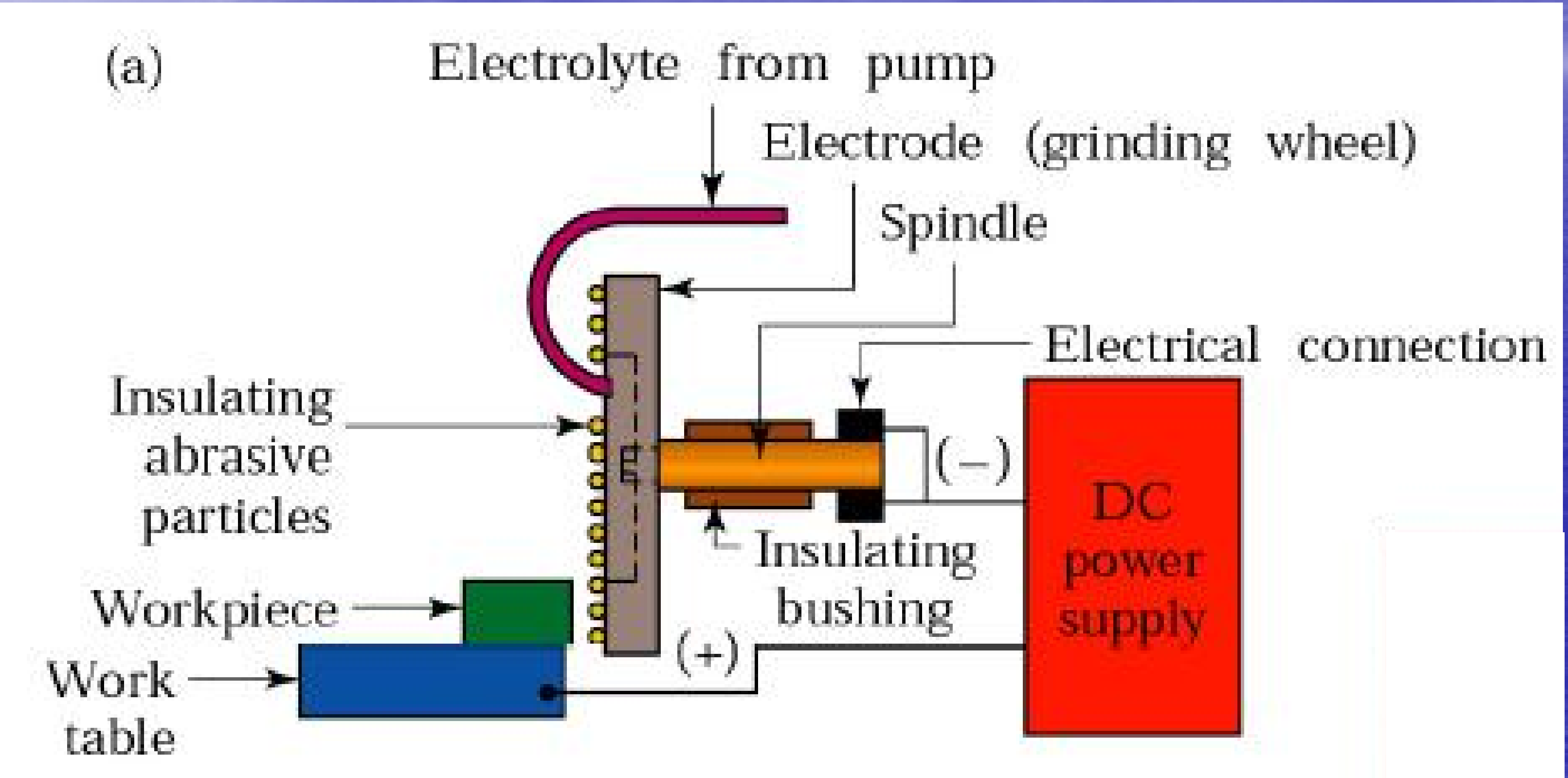


Fig. 12.1 Schematic diagram of electrochemical grinding set-up.


Wheel
Voltmeter
Insulation
Nozzle
Spraying
Electrolyte
D.C.
Power
Supply
Ammeter
Workpiece
Work pan
Flowmeter
Pump
Clarification
Reservoir

ECG - Combines electrochemical machining with conventional grinding



<u>Fig</u> : Schematic illustration of the electrochemical – grinding process

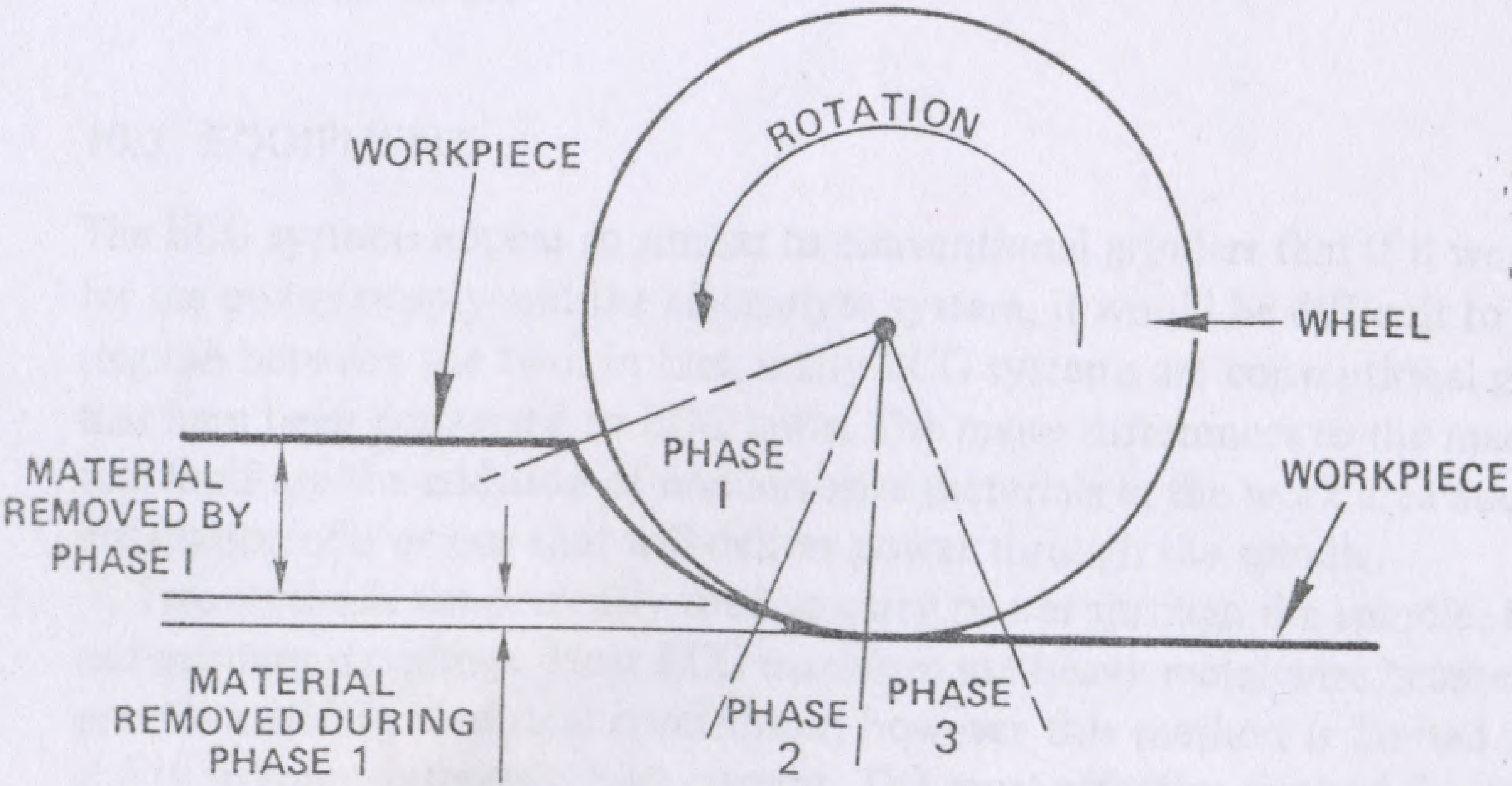


Figure 10.3 The three phases of ECG material removal.

Major components of the system

- Electrolyte delivery and circulating system
- Electrolyte
- DC power supply
- Grinding wheel
- Work piece

Electrolyte delivery and circulating system

- The electrodes are not totally immersed, yet there must be an ample supply of electrolyte
- Nozzles are used to ensure proper wetting action of the wheel
- Nozzle creates a partial vacuum and causes the electrolyte to be sucked up, filling the cavities around the grit – the rotation of the wheel then carries the electrolyte into the area of contact between the workpiece and the wheel

Electrolyte

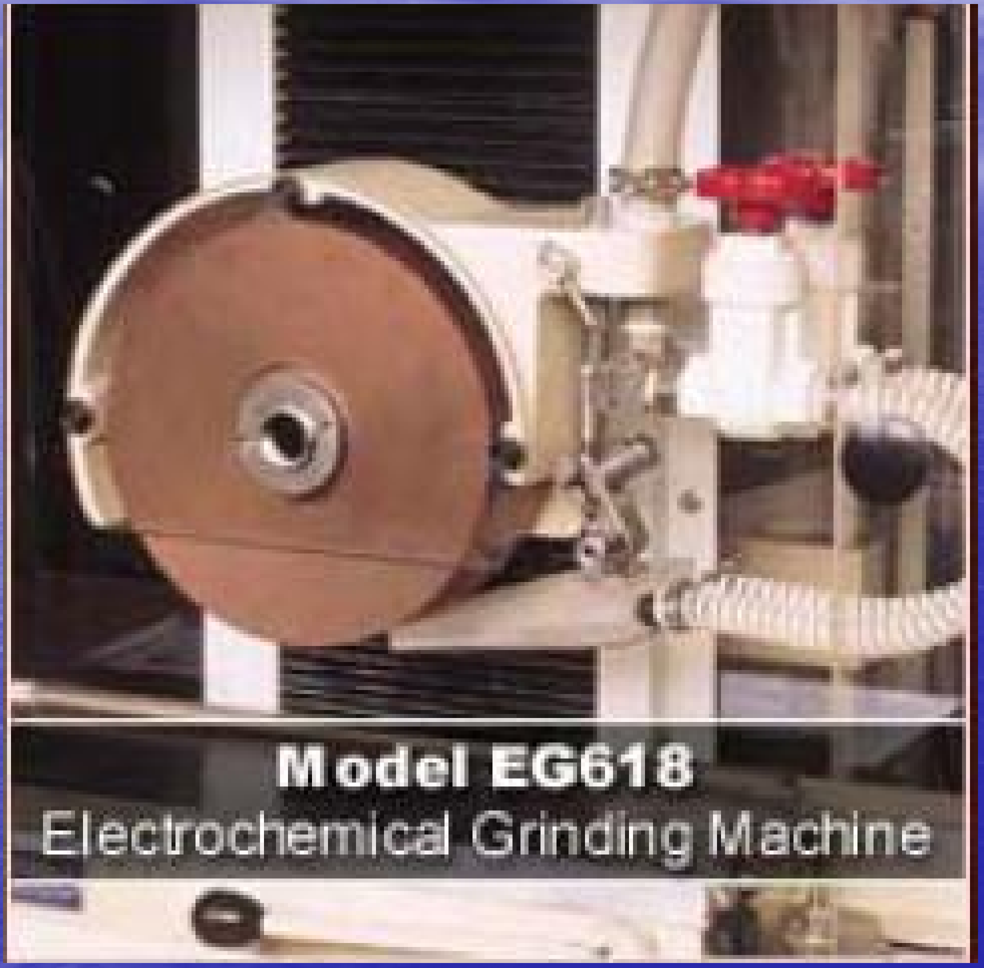
- Resemble those used for the ECM; however formulations for ECG are distinctly different – they are designed to enable faster formation of oxide films on the workpiece, whereas in ECM, the oxide must dissolve at once in the electrolyte
- Desirable electrolyte should provide: high conductivity, high stock removal efficiency, passivation to limit stray currents, good surface finishes and corrosion inhibition

Grinding wheel

- The abrasive grains on the ECG wheel serve three major purposes:

1. Act to wipe the oxide from the workpiece, exposing new metal and allowing the process to continue
2. Spacer to keep the conductive media in the wheel from making direct contact with the workpiece and generating a short circuit
3. The cavities between the grit are filled with electrolyte, and the grit acts as a carrier bringing the electrolyte to the work area between the workpiece and the wheel making the ECG process possible

- ECG wheels are made of an abrasive material, a bonding agent and a conductive medium
- Most ECG wheels have aluminium oxide as the abrasive and contain copper impregnated resins for conductivity
- Other abrasive materials used include silicon carbide and diamond and recently borazon


Model EG618
Electrochemical Grinding Machine

Methods

- Five different grinding methods can be performed with ECG equipment: face grinding, surface grinding, internal grinding, form grinding and cylindrical grinding

Process parameters

- ECG exhibits MRRs that are up to 10 times faster than conventional grinding on materials harder than 60HRC; although MRRs are high, ECG cannot obtain the tolerances achieved by conventional grinding
- The removal rate for ECG is governed by the current density, just as in ECM: as with ECM, the higher the current density, the faster the removal rate and the better the resulting surface finish
- Feed rates vary with different parameters, depending on the grinding method: if the feed rate is running too slowly for the application, a large overcut will be produced that will result in poor surface finishes and tolerances and if the feed rate is too fast, the abrasive particles will be prematurely forced into the workpiece, resulting in excessive wheel wear

Advantages

- No thermal damage to workpiece
- Elimination of grinding burn
- Absence of work hardening
- Long-lasting wheels – less truing
- Higher MRR;
- Single pass grinding - reduced cost of grinding;
- Absence of burrs on the finished surface;
- Improved surface finish with no grinding scratches;
- Reduced pressure of work against the wheel – no distortion;
- In ECG, the ECM action is efficient

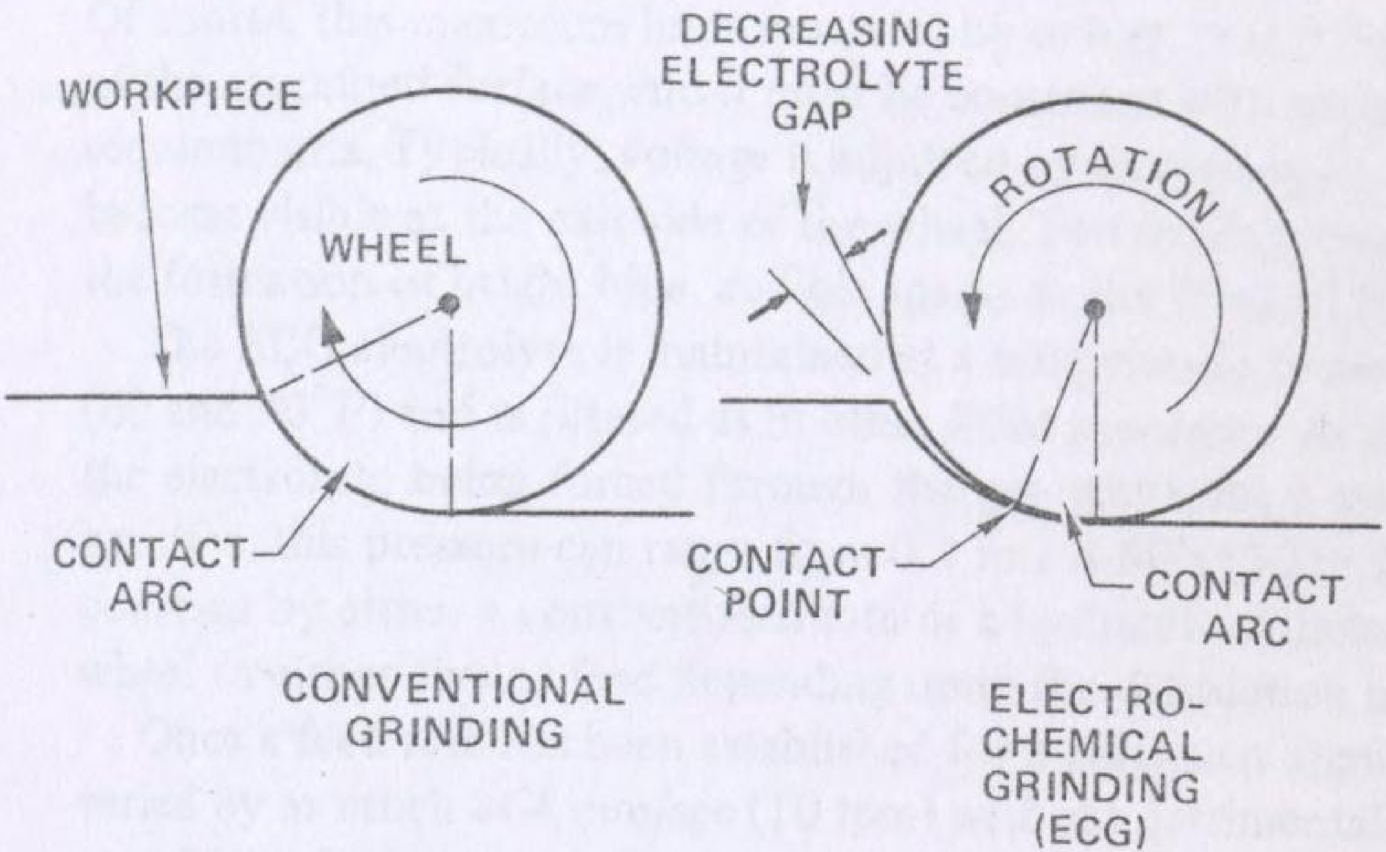


Figure 10.2 A small mechanical contact arc is partly responsible for the long wheel life experienced by ECG users.

Limitations

- High capital cost / Higher cost of grinding wheel;
- Corrosive environment
- High preventive maintenance cost
- Tolerance achieved are low;
- Difficult to optimize due to the complexity of the process;
- Non-conductive materials cannot be machined
- Not economical for soft materials – noncompetitive removal rates compared to conventional methods for readily machinable metals
- Requires disposal and filtering of electrolytes

Applications

- Single largest use for ECG is in the manufacturing and remanufacturing of turbine blades and vanes for aircraft turbine engines
- Grinding of tungsten carbide tool inserts
- Re-profiling worn locomotive traction motor gears
- Burr-free sharpening of hypodermic needles
- Grinding of surgical needles, other thin wall tubes, and fragile parts
- Machining of fragile or very hard and tough material – honey comb, thin walled tubes and skins
- High MRR’s when grinding hard, tough, stringy, work-hardenable or heat sensitive materials

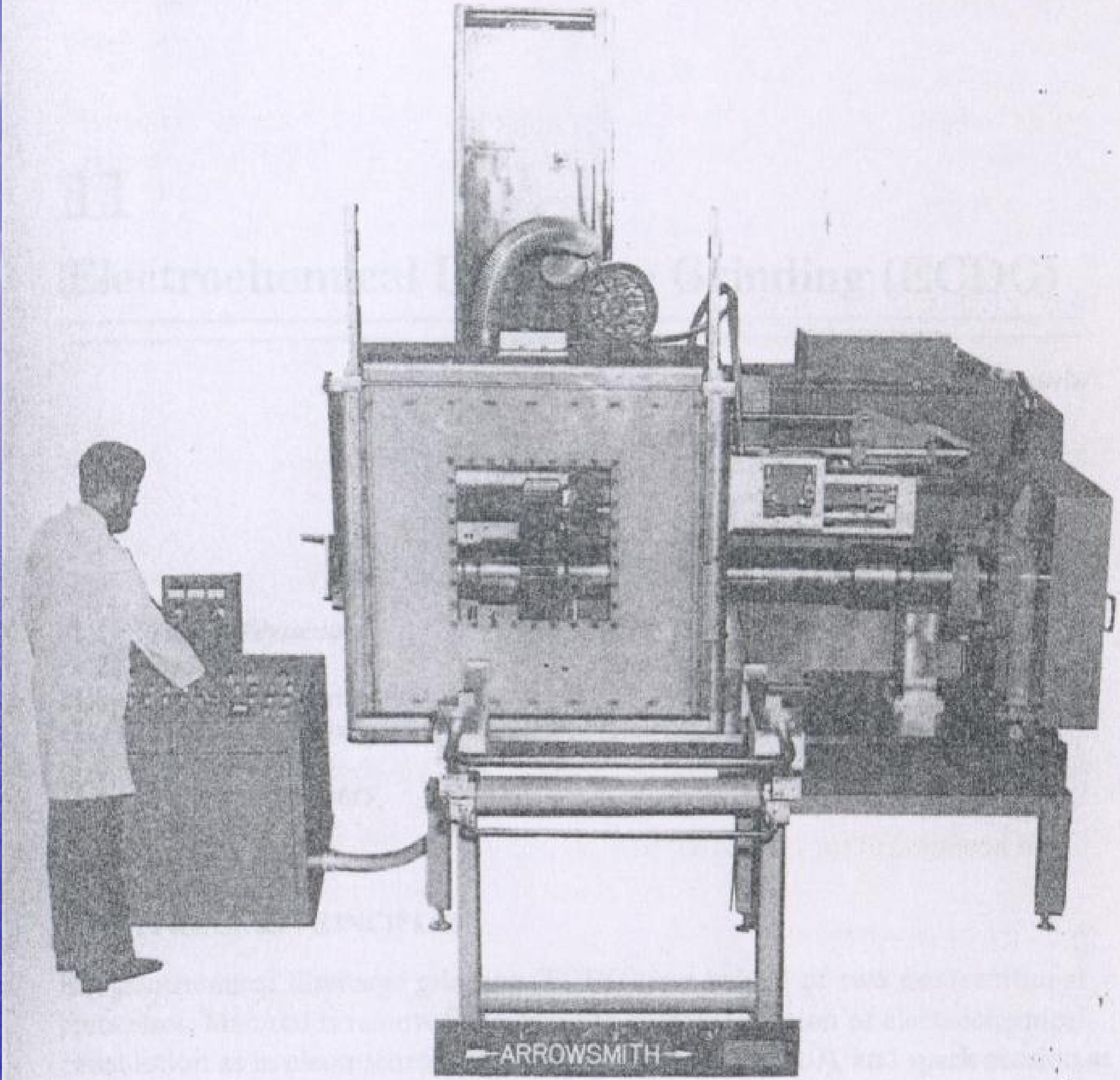


Figure 10.8 An ECG system used to reprofile locomotive traction motor gears (*Source:* courtesy, Arrowsmith Industries, Inc., Los Angeles, Calif).

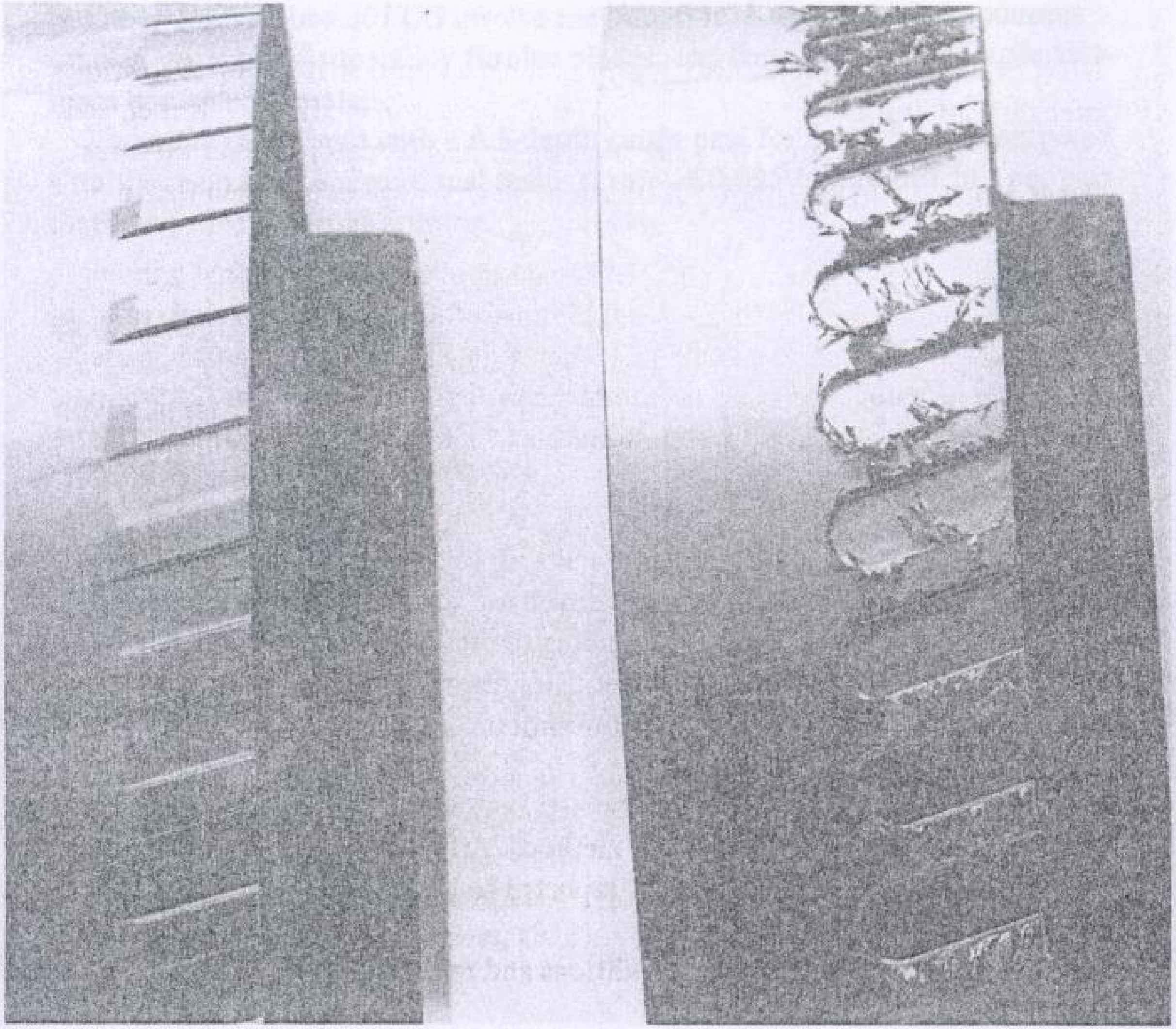


Figure 10.7 Two identical gas turbine components made from a tough superalloy. The part on the left had the slots produced by ECG. The part on the right was produced by conventional milling. The slots produced by ECG require no postprocessing or cleanup operations (*Source:* courtesy, Garrett Turbine Engine Company, Phoenix, Ariz).

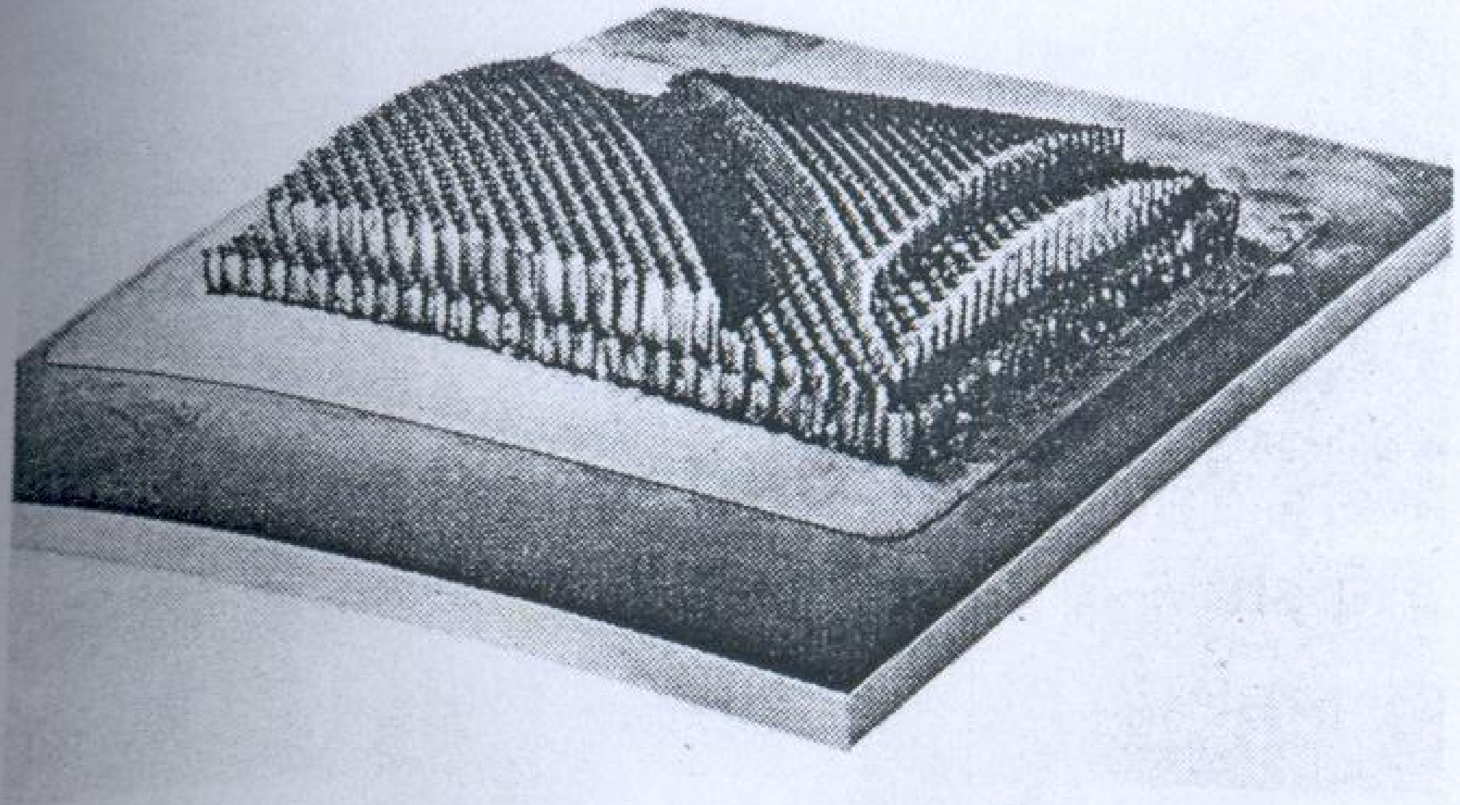


Fig. 3–14. Contoured stainless steel honeycomb, shaped by ECG. *(Courtesy, Anocut Engineering Company)*

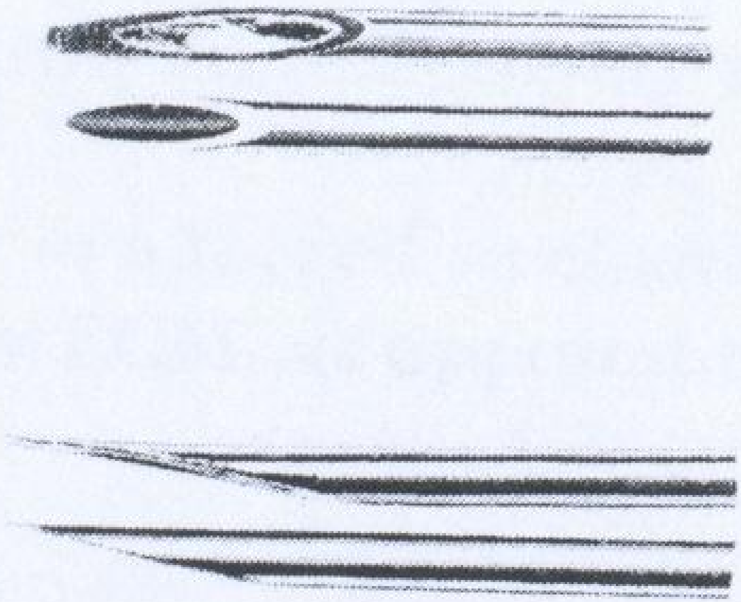


Fig. 3–15. Hypodermic needles (left) sharpened by ECG without burrs. Needles at right were conventionally ground at same speed (note burrs). *(Courtesy, Anocut Engineering Company)*

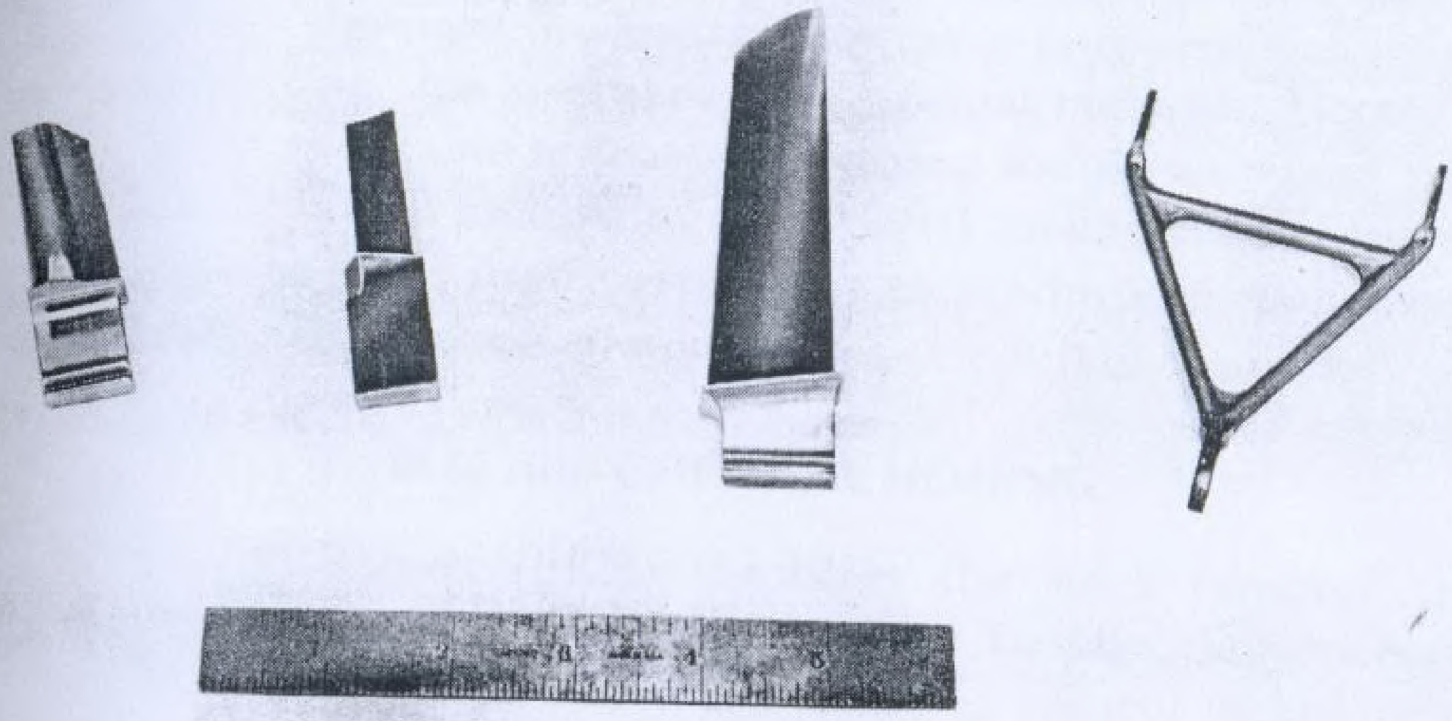


Fig. 3–16. Jet engine parts electro-chemically ground faster than conventional milling with virtually no tool cost. *(Courtesy, Anocut Engineering Company)*

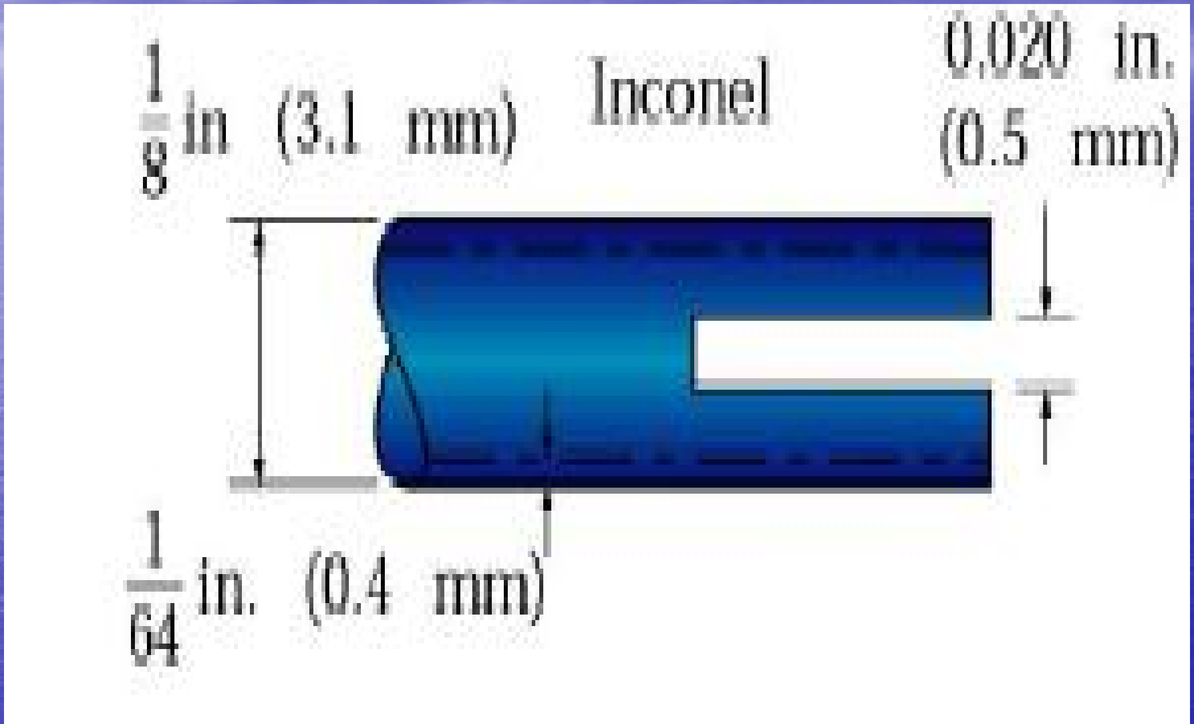


Fig : Thin slot produced on a round nickel – alloy tube by this ECG

ECG parts