

**SOUTHWIRE COMPANY
METALLURGICAL LABORATORY**

***ENCYCLOPEDIA
TEARS OF COPPER WIRE***

**by
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and
Gautam R. Patel**

*Dedicated to: D. B. Cofer
Senior Vice President Southwire Company*

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PREFAZIONE

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The encyclopedia of the copper wire breakages was prepared to better classify different types of breakages and to provide for a better understanding of / and probable / the cause / s and origin / s.

The encyclopedia contains a classification and definition of tears, photographs of actual fractures, causes and origins of fractures, taken from real ruptures, the causes, origins, from various and actual cases and actual cable break references.

In some examples the wire breakages have occurred while trafilava the wire rod and / or the copper wire and their rupture causes were easily traceable.

Other samples of breakage were provided by different wire mills from around the world and examination on fracture were carried out by legally accredited studies that have provided the necessary information to classify the defect and discover its origin.

The optical scanning electron microscope (S. E. M.) and the X-ray technique were used in order to classify and determine the / and cause / and broken.

The goal of the authors is that this compendium will provide a wire drawing process and the engineers with the necessary information to improve their quality and workmanship.

This goal will be achieved by a better understanding of failure mechanisms and recognize the potential area of process-related problems and the product, which may occur during the drawing.

In conclusion, the authors wish to show great gratitude to the many colleagues who have contributed to this work.

Special mention to Mr. D. B. Cofer for the useful tips and gentlemen Bobby Gentry, Gerald Hudson, Doug Cole, Jerry Tolbert and Bobby Workman

January 1, 1985 E. Henry Chia

G. R. Patel

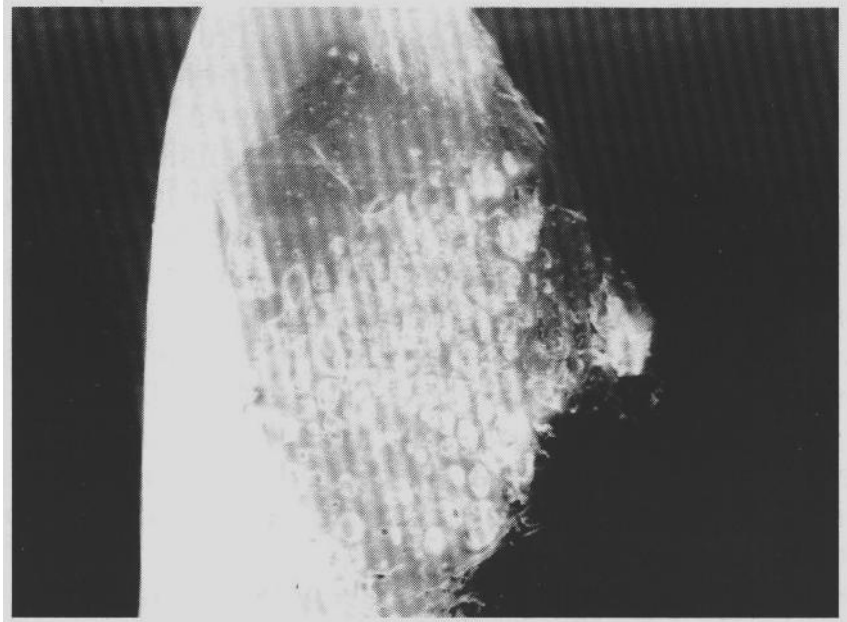
**CLASSES FOR BREAKING THE MERGER WIRE ARC
VOLTAIC**

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yarn breakage characterized by the formation of an electric arc (electrical scintillation) during the continuous annealing in the resistance to electric oven resulting in partial or complete melting of the copper wire



Fusione localizzata che si è verificata durante la ricottura del filo, in continuo.

CAUSE / E:

- 1- contaminated ring surface of the furnace of the pulley contact.**
- 2- inadequate tensioning of the wire by the compensator or "dancer"**
- 3- pulley or the oven contact strip off-center or not fitted properly**

ORIGIN / I:

- 1- pulley oven**
- 2- bobinatore**
- 3- retirement check**

CLASS II

- RIP-Centrale-

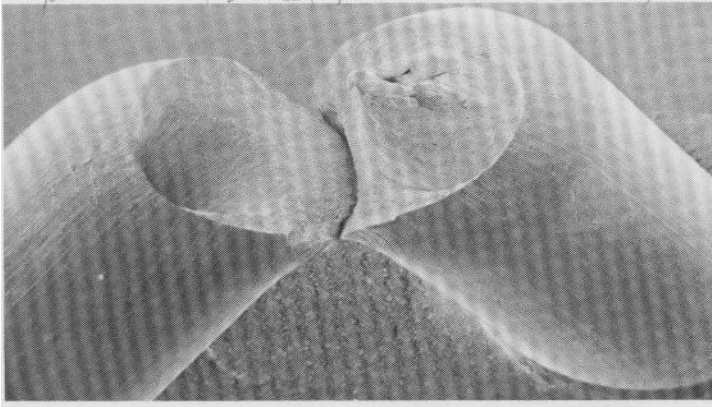
OTHER NAMES: Cuppy BREAK; BREAK CUP-CONE

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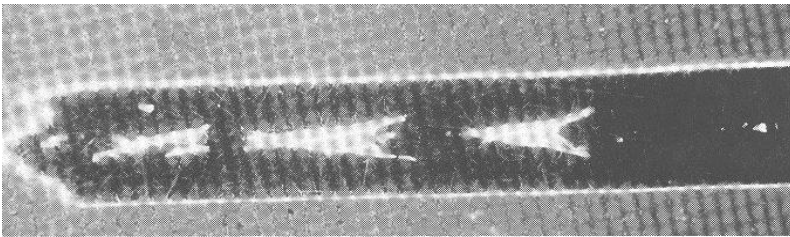
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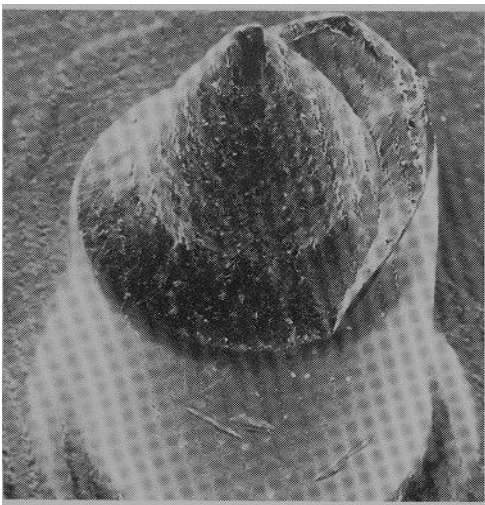
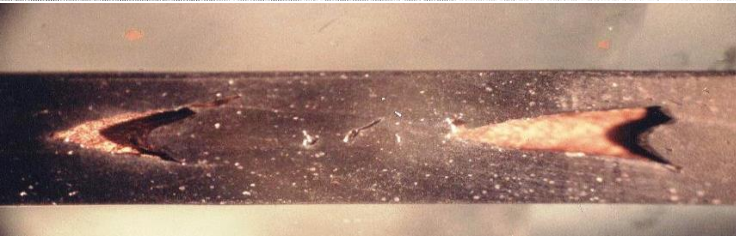
Fracture of the wire characterized by the formation of a cutting lip which covers 180 ° of the circumference of the wire and contains a cone as a protrusion in the central portion of the rupture.



Two adjacent surfaces of a typical cup-cone failure (Central tear)



Longitudinal section of a wire showing the formation of defects: central tear (cup-cone)



end portion of the rupture cone "cup-cone"



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Porzione della rottura coppa-cono
Che Mostra La Cavita (coppa)

CAUSA / E:

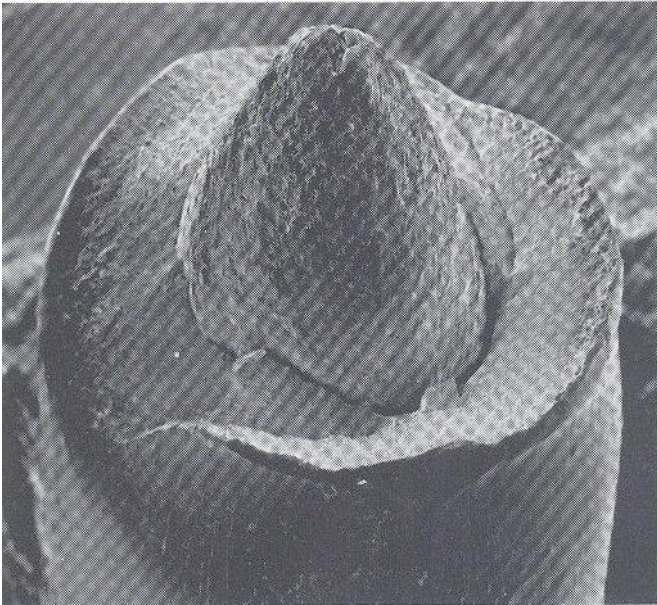
- 1-alta concentration di particles o stringhe di ossiduli di Rame Nella vergella.
- 2-Presenza Di Una micro-particella di inclusione (magnetica o non-magnetica)
- 3-geometria della filiera non Corretta, cabestani usurati, errata Linea d'entrata del filo Nella filiera

ORIGINE / I:

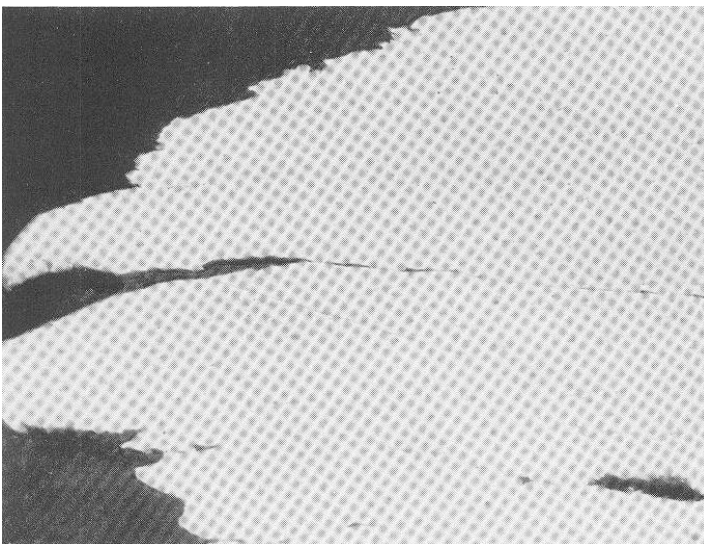
- 1-tenore eccessivo di ossigeno Nella vergella (Superiore ppm 600 (VEDERE IIA)
- 2-delle scaglie di ossido di rame potrebbero Essere cadute nel rame liquido Nella paniera, Durante la colata.
- 3-un grappolo di OSSIDI di rame del beccuccio di colata, potrebbero Essere caduti nel rame liquido sottostante (VEDERE IIA)
- 4 Grappoli di scaglie di ossido di rame, formatisi Attorno al Foro del bruciatore a gas, potrebbero Essere Caduti Nella colata.
- 5-disomogenea dispersion o Distribuzione delle ossiduli di Rame Nella Matrice, causata dal Sistema di raffreddamento ruota-Barra non appropriato.
- 6-micro particles (Magnetiche o non Magnetiche) rimaste solide (non liquefatte) nel Rame Contenuto Nella paniera di colata (VEDERE II B)
- 7-particles metalliche provenienti Dalla trafilatrice a freddo

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CLASS III
SUB CLASS A
RIP CENTRAL (CUP-CONE) INDUCED BY PARTICLES
OF COPPER OXIDE



A portion of the central cone cup-cone failure



High concentration of particles of copper oxide present in the cup-cone fracture zone



High concentration of strings of copper oxide particles present in the area of the cup-cone fracture

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Segregations of large and small copper oxide particles in the cup-cone fracture zone

CAUSE / E:

1- High concentration of particles or copper oxide strings in the central portion of the thread. These particles act as a point of origin where the focus is to initiate a micro-crack which will propagate during the drawing up to occur in the yarn breakage.

ORIGIN / I:

- 1- excessive rate of oxygen content in the wire rod (greater than 600ppm)**
- 2- flakes of copper oxide falls within the liquid copper in the tundish**

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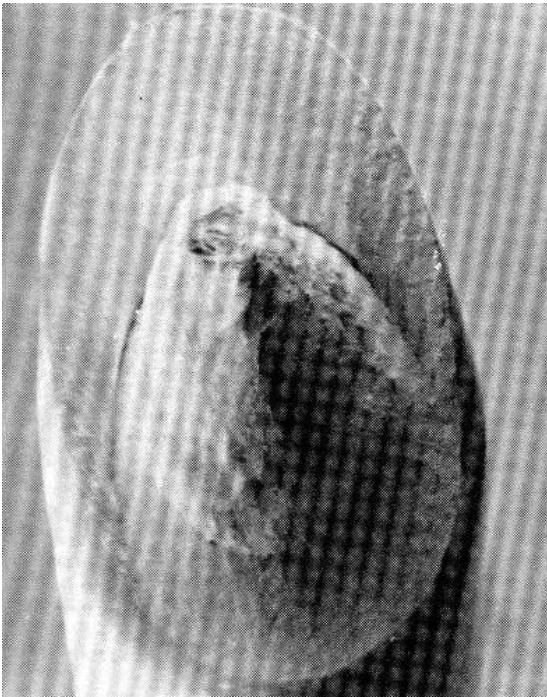
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- 3- oxides circumferential of the pouring spout that have fallen into the liquid copper bar.
- 4- Bunch of copper oxide particles from the burner hole, have fallen in the liquid of the copper bar.
- 5- Incostante and uneven distribution of copper ossiduli in the matrix, caused by cooling inappropriate wheel / bar

CLASS II

UNDER CLASS B

**RIP CENTRAL (CUP-CONE) INDUCED BY MICRO-
INCLUSION (MAGNETIC OR
NON-MAGNETIC)**



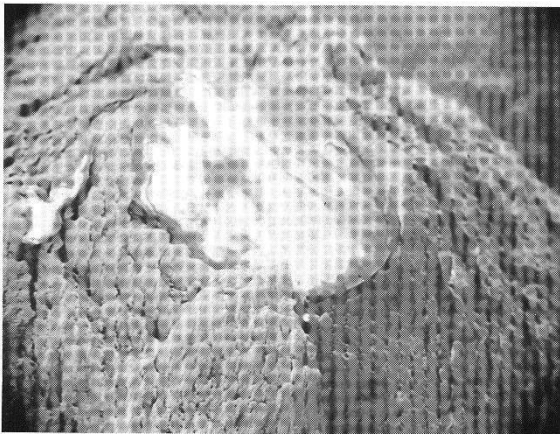
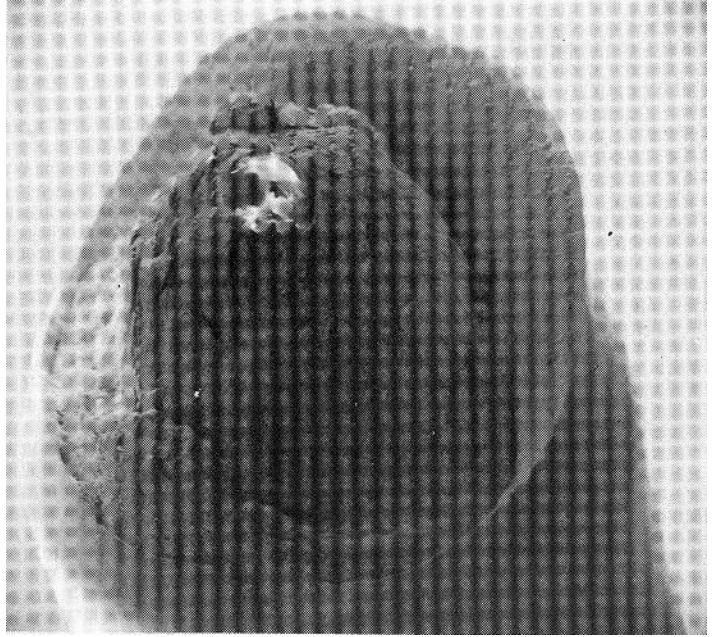
**the cone portion of a cup-cone failure
produced by a non-magnetic micro-
inclusion**



**high magnification
photograph of silicon-
based particle (likely
SiO₂)**

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Portion of farm fracture
central
Showing micro particle inclusion
Of non-magnetic material.



Photograph of a fracture caused by particle
containing **Ai-Si-Ti**

CAUSE / E:

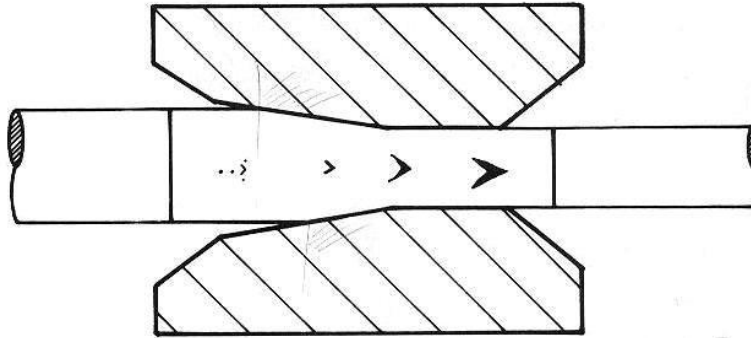
1- presence of micro particle of inclusion (composed of aluminum, silicon and titanium, in this case) that caused the crack during the drawing

1- ORIGINE/I:

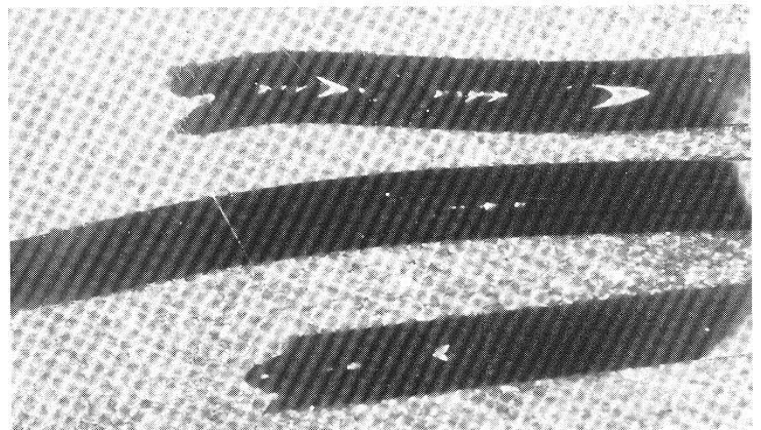
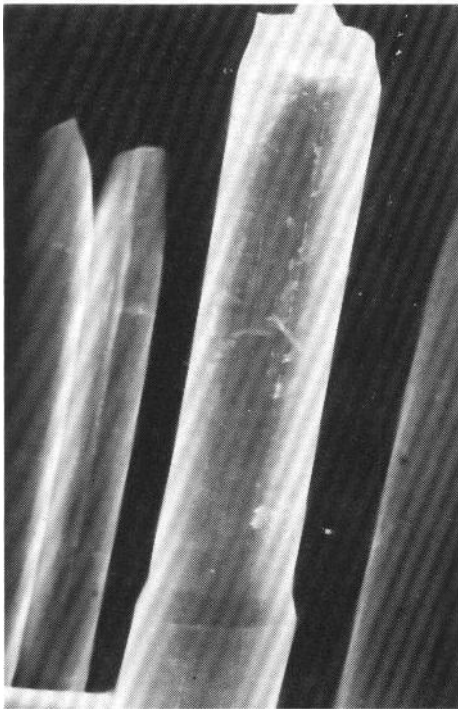
2- dal beccuccio di colata

3- dalla panierà, dai canali adduttori del rame liquido, dai refrattari del rivestimento del forno fusorio

**CLASS III
SUBCLASS C
RIP CENTRAL (CUP-CONE) DUE
THE PARAMETERS OF DRAWING WRONG**



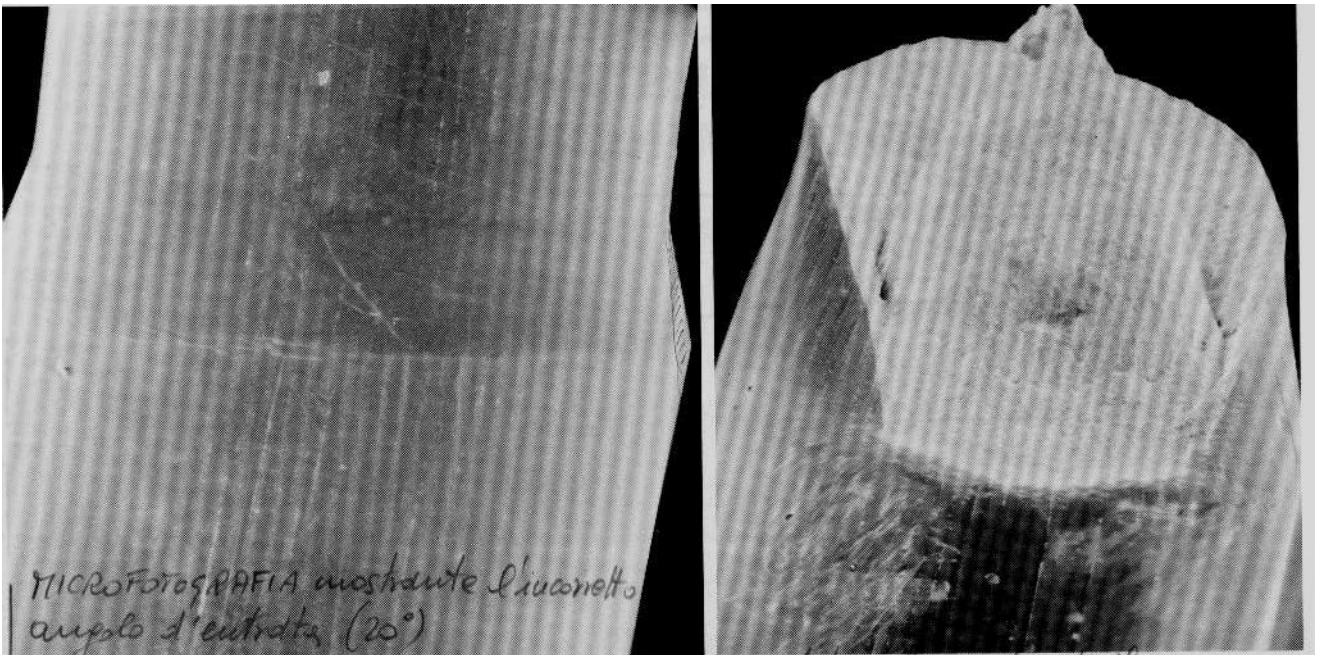
OUTLINE OF THE MECHANISM OF "RIP CENTRAL" BREAKING
"COPPA-CONE"



Macrograph of the longitudinal section of a cup-cone failure, where the "tear - central" lying on the longitudinal axis of the wire, caused by the angle of the incorrect chain reduction cone (20°) are visible

**Photomicrograph of fractures
Caused by the central blast caused
Since incorrect angle of reduction
Of the chain (20°)**

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**Macro showing cup-cone break a cone semi-angle caused by angle
Incorrect chain reduction ($\alpha = 20^\circ$) chain reduction too open.**

CAUSA/E:

- 1- excessive hydrostatic stress in the central portion of the thread during the drawing.
- 2- Force counterinsurgency increased traction
- 3- Reduction of insufficient section
- 4- Inadequate angle geometry of the chain reduction cone.
- 5- excessive angle of the incoming wire chain
- 6- Friction increased by insufficient lubrication and / or reduction rate or corner is not properly entered.
- 7- excessive length of the cylindrical part of the chain surface
- 8- very worn Capstans

ORIGIN / I:

conduction of the technique and the drawing line management.

the origin of these wire breaks reside precisely in the excessive (semi) -angle of chain reduction ($\alpha = 20^\circ$)

CLASS III
FLUSH WITH SURFACE INCLINE

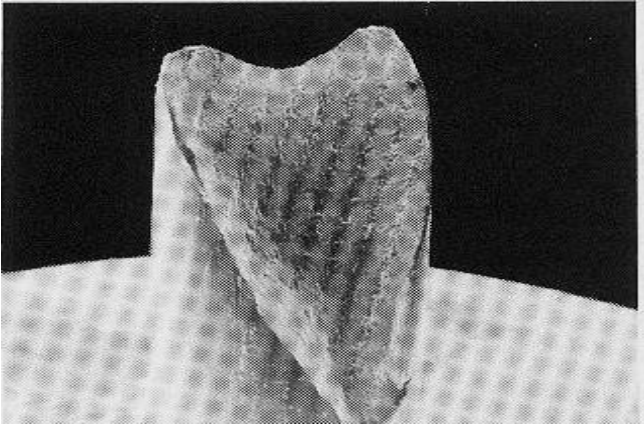
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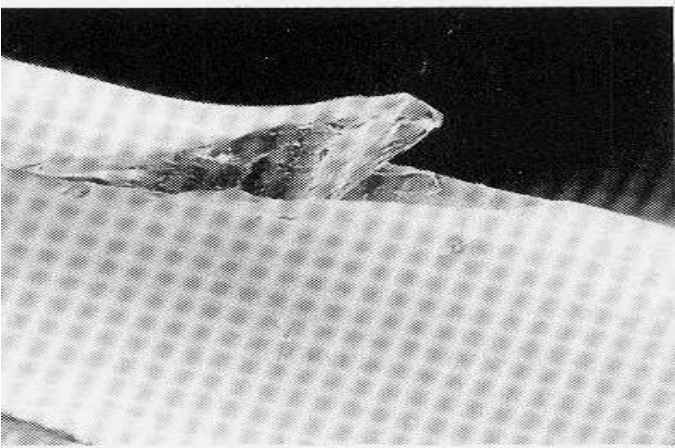
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**OTHER NAMES: ARROWS, CROW FEET OR DEFECTS
IN THE SHAPE OF "V"**

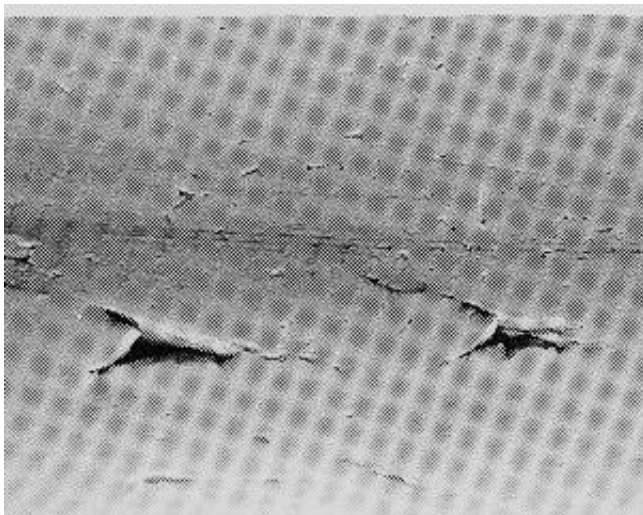
Defects on the wire characterized by a fracture in cutting, usually at 45° to the axis of the wire, which practically does not exhibit any reduction of area in the fracture area



Fracture type cut, started by a defect in the shape of an arrow

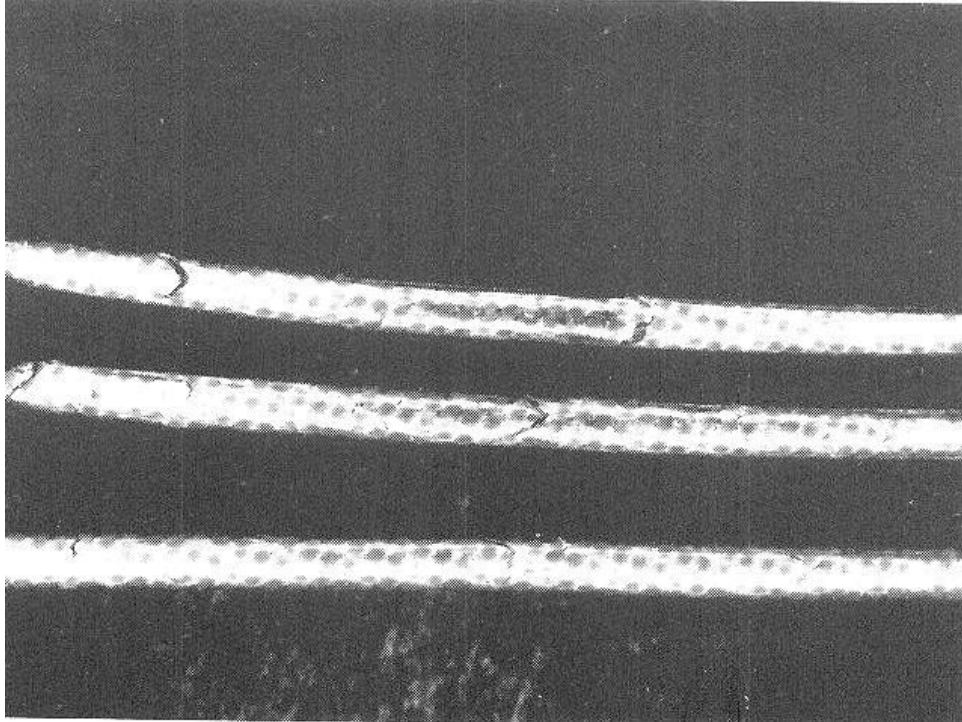


Eruption on the surface of a pointed defect of arrow, appeared after many drawing steps.



Defect in the shape of "V", On the wire surface

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A flush with the inclined surface shows cracks in a "V-shaped" that will cause thread breakage.

CAUSE / E

- 1- Defectiveness of burning on the surface that represent the points di'inizio of thread breakage.
- 2- 1- strands of wire having hardened surface
- 3- 2- profile Inappropriate chain
- 4- 3- approach angle and reduction in the chain not perfectly coupled
- 5- 4- length of the cylindrical die too short.
- 6- 5- incorrect wire-chain alignment
- 7- 6- Rubbing and grooves of the wire on the outside and / or inside the machine.

ORIGIN / I

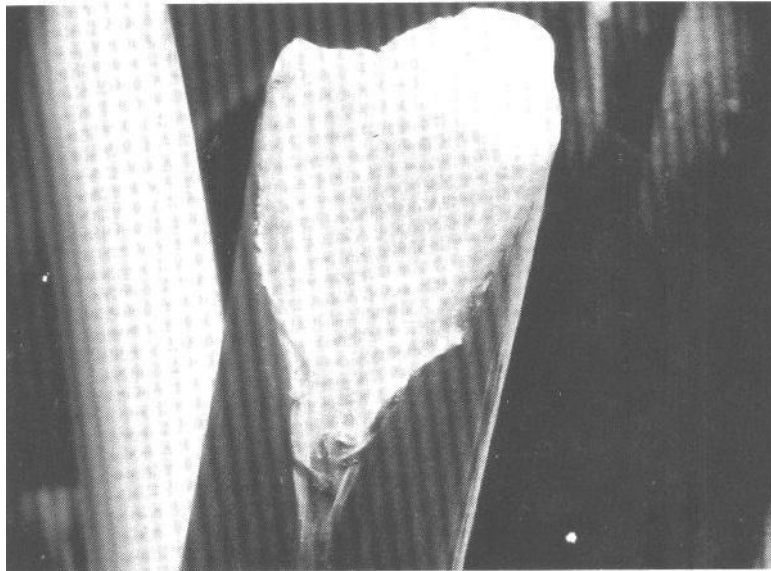
- 1- cracks that are
present on the bar.
- 2- cracks that form in the rolling stands.
- 3- Micro-cracks that form during the cold drawing
- 2-

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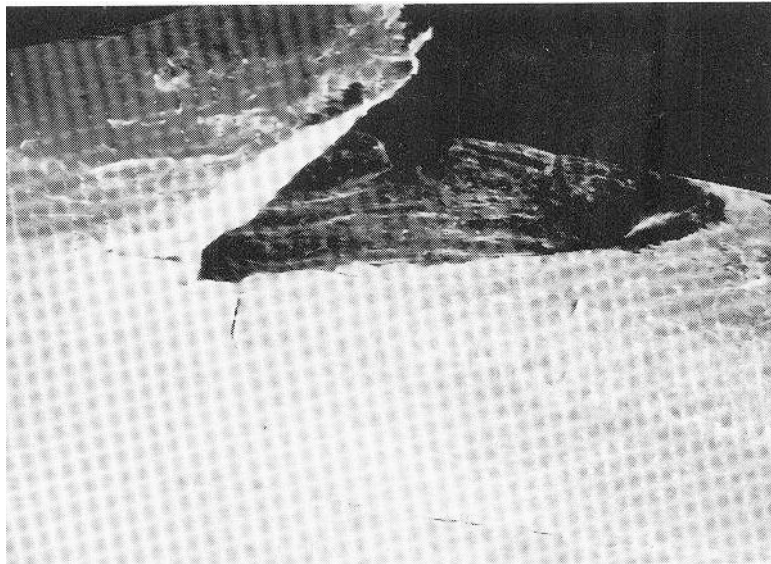
CLASS III

SUB CLASS A

**BROKEN RESULTING FROM THE SURFACE INCLINE.
OXIDES IN A BAR CASTING PRODUCED STARTING
FROM WIRE BAR (NOT BY CATHODES)**



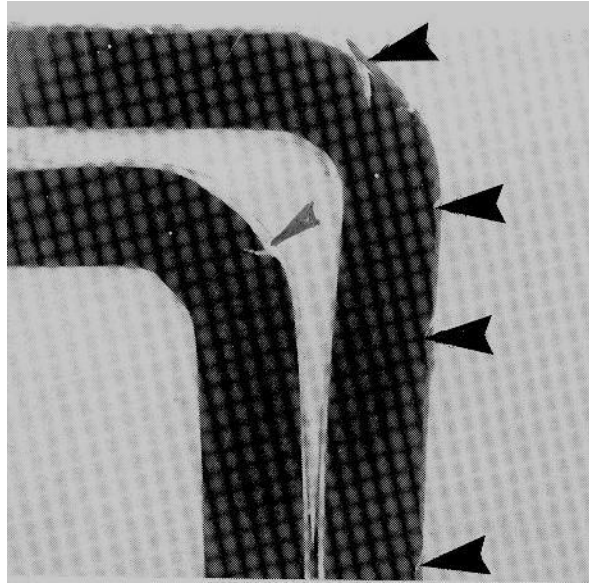
**Cutting
resulting
defects in
"crow's**



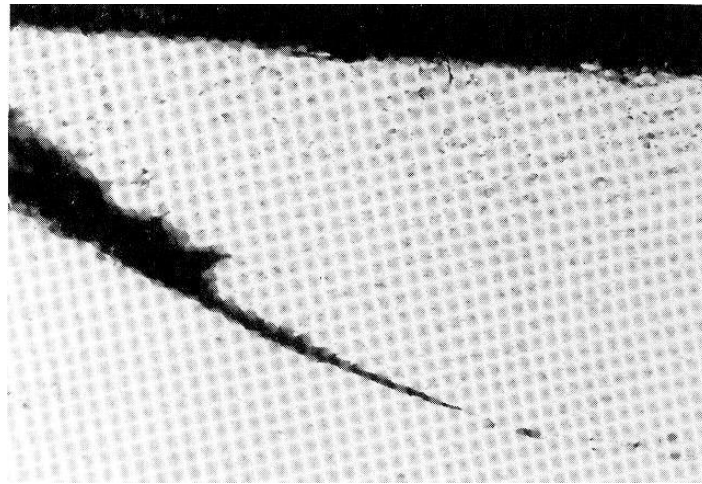
**breakage
from surface
the form of
feet"**

eruption on the surface caused by a defect in "crow's feet"

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longitudinal section, of wires which have been bent specifically, where the surface cracks are clearly visible caused by a set of oxides hidden skin".



which were "under the

A set of surface oxides is clearly visible in the "crow's feet" in the form of cracking section.

CAUSE / E:

-presenza di un'alta concentrazione di ossidi sulla superficie della vergella

ORIGINE/I:

-insieme di ossidi superficiali oppure utilizzo di wire-bar (al posto dei catodi)

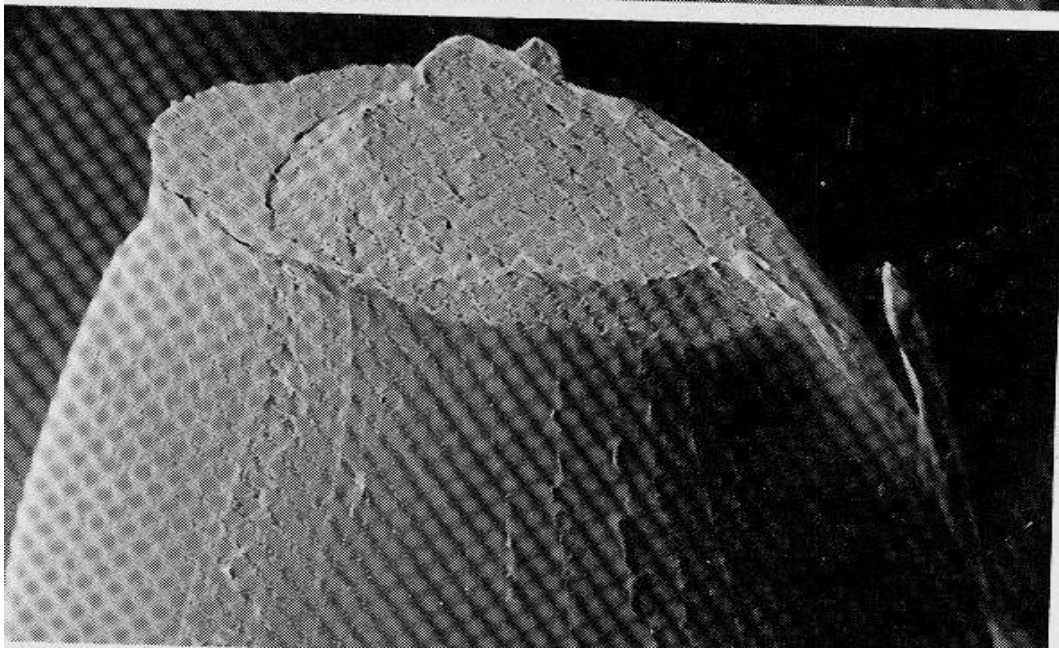
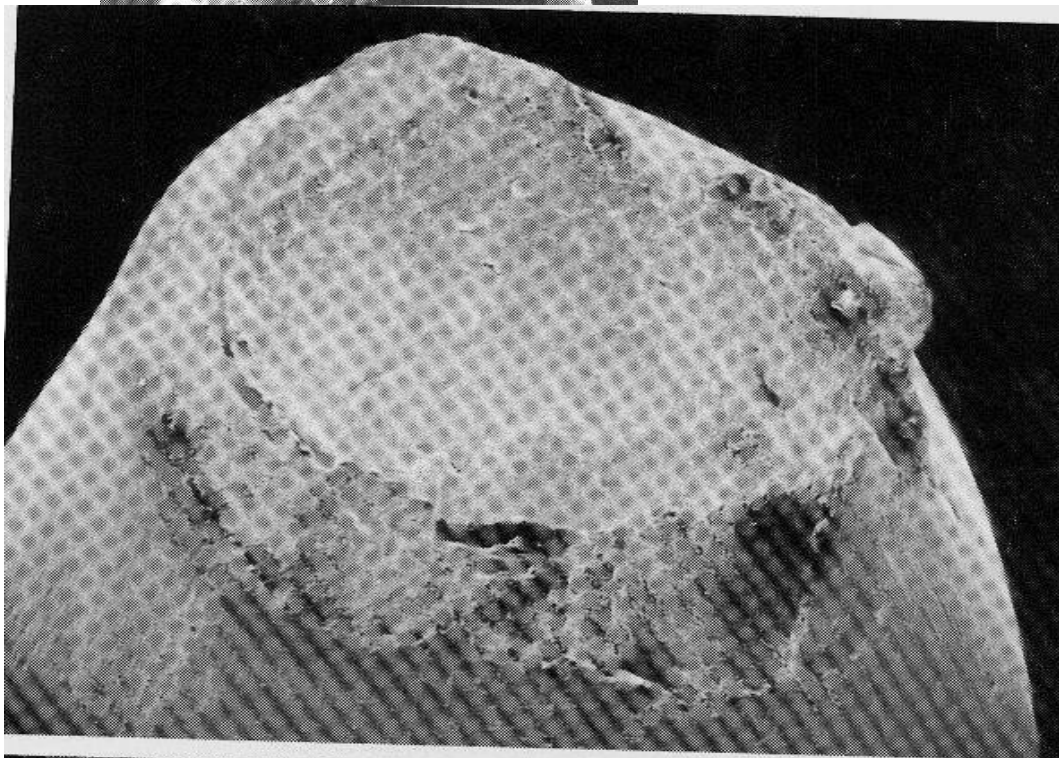
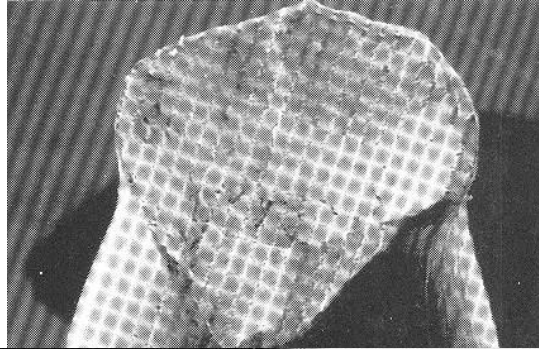
CLASS IV

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COMPOUND FRACTURE

Fractures caused by typically resulting axial tension in the area affected by the reduction of the wire section.

However, the breakdown shows defects (fine burrs) in the vicinity and on the adjacent surface.

The defects are the places of origin of the break.



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CAUSE / E:

fine burrs and specks on the wire surface or present on wire rod or produced during the drawing operations.

1- ORIGIN / I:

- 2- 2- defects on the surface of the wire rod
- 3-** practice of conducting the draw bench

CLASS V

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TEARS FOR INCLUSION

the yarn defect characterized by the presence or by the previous presence (absence) of inclusions on the fracture surface.

The yarn break can have magnetic inclusions, non-magnetic inclusions or a combination of both and can exhibit different shape of the rupture

CAUSE / E

- 1- inclusions magma flows and rolled into the copper wire rod
- 2- Non-magnetic inclusions (of copper oxide scales, slag and refractory particles coming from the melting furnace or by adductor channels) flows and rolled into the copper wire rod
- 3- incorporated inclusions in the wire rod by rolling rolls (fragments of cast iron, of steel cylinders and from other parts of the plant)
- 4- incorporated inclusions inside the wire drawing (hard foreign particles which are present in chains or in the lubricating-coolant solution.

1- ORIGIN / I:

- 2- strapping steel or segments of seals introduced during the loading of the cathodes
- 3- fragments detached from the auction of regulating fluid flow in copper casting
- 4- of steel wires used to free the outlet of the pouring spout
- 5- steel specks from the floor on which vines are scattered, bolts, nuts etc .etc.
- 6- erosion of the orifices of the gas burners of the melting furnace
- 7- droplets sprayed away during a welding repair of the oven
- 8- tiny chips, flakes and particles that come out from worn laminating rollers or criccati
- 9- refractory particles of the melting furnace
- 10- refractory particles from the feed channels material from the casting spout
- 11- accumulation of copper oxide on the pouring spout
- 12- particles introduced by the load operation
- 13- of copper oxide particles, scraped from the solidified bar from the upper conveyor, falls inside the tundish casting.
- 14- particelle oxide that are formed in the micro-cracks on the bar in the first steps of rolling.
- 15- hard foreign particles (magnetic or non-magnetic) that are present in chains or in the lubrication-cooler, specks on the floor, fragments of broken wire.

**CLASS V
UNDER CLASS A
THIS THREAD WITH INCLUSION**

the yarn defect characterized by the presence of inclusions (magmatic inclusions, non-magnetic inclusions or a combination of both) on the fracture surface.

**UNDER A - 1 CLASSE
FRACTURE INDUCED BY THE PRESENCE OF
INCLUSION MAGNETIC**



Micrograph of the wire breaking showing a large piece of inclusion of Fe.

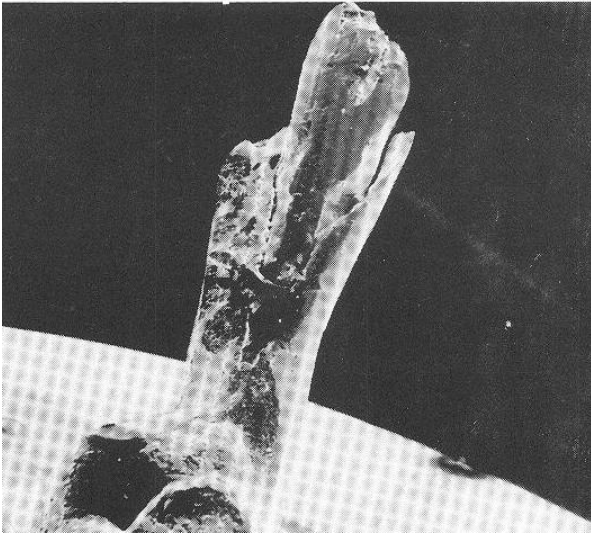
CAUSE / E:

- 1- a large piece of inclusion of cast iron and rolled in copper wire rod
- 2- Inclusion of steel from the cylinders and by other organs of the system steel
- 3 fragments of cast-iron from operational bodies on the machine

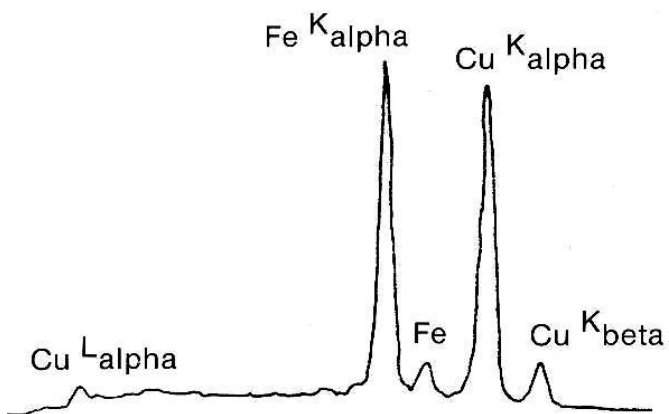
ORIGIN / I:

- 1-reggette steel or fragments of seals introduced with the load cathodes
- 2- rod erosion of copper flow adjustment
- 3- Wireless usta iron to gush the hole of the pouring spout
- 4- flakes and specks of steel wire from dirt on the floors
- 5- deterioration of the orifice of exit of the flame of the gas burner in the melting furnace.
- 6- steel falls drops in the oven during electric arc welding for the repair
- 7- small chips, flakes and particles fall out of the cylinders that are worn out.

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The U. S. M. micrograph of a break for inclusion

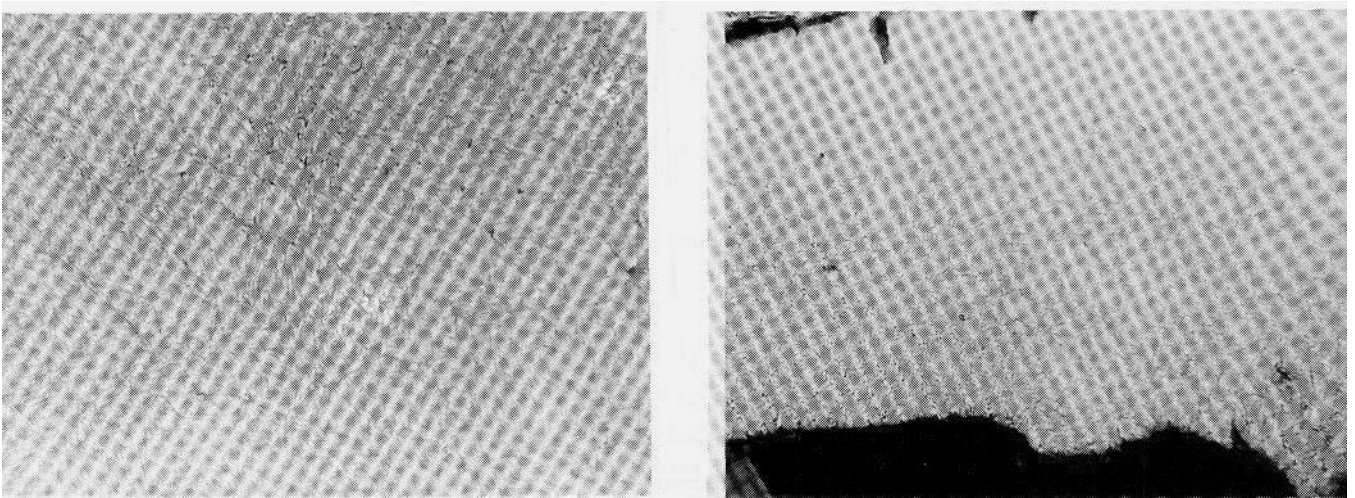


Microanalysis to S. E. M. area of inclusion Which one shows the presence of iron and copper.

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**IDENTIFICATION MICROSTRUCTURE Of Different
Types Of Magnetic inclusion**

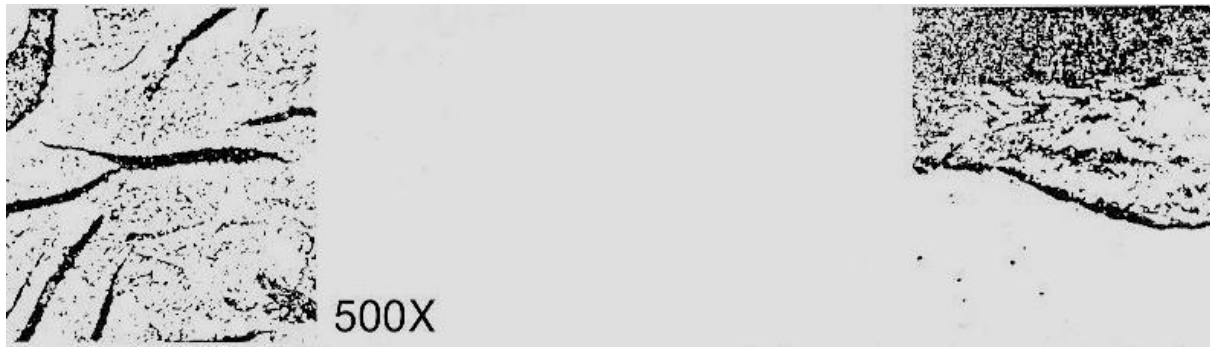


Ferrous inclusion in a copper wire having 0.254mm diameter (Nikon attack)



Inclusion in a ferrous wire having 0,559mm diameter, identified as Fe-Cr (4-6%); Mo (1-2%); V (0.8-1.5%); corresponding to: H13 stainless steel cylinder; . (Nikon attack)

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Microstructure of cast iron
gray pearlitic showing perlite
And some flakes
graphite

Comparison of microstructures of ferrous materials of the wire rod mill and some very similar, made on inclusions found in wire breakage (ref. 8)

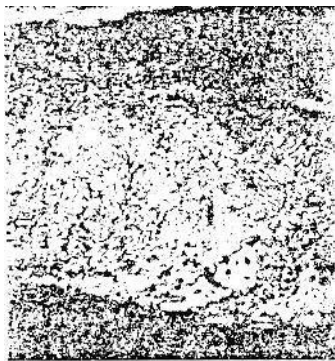


Microstructure of the capstan Macrostructure inclusion of the drawing machine that found in an exhibition tempered martensite break showing tempered martensite.

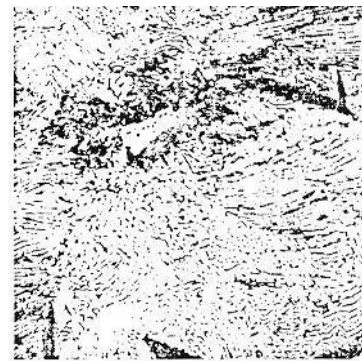


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microstructure of the capstan macrostructure inclusion machine made with rott found in steel. wire displays by tool, showing tempered martensite and tempered martensite and carbides. Carbides.



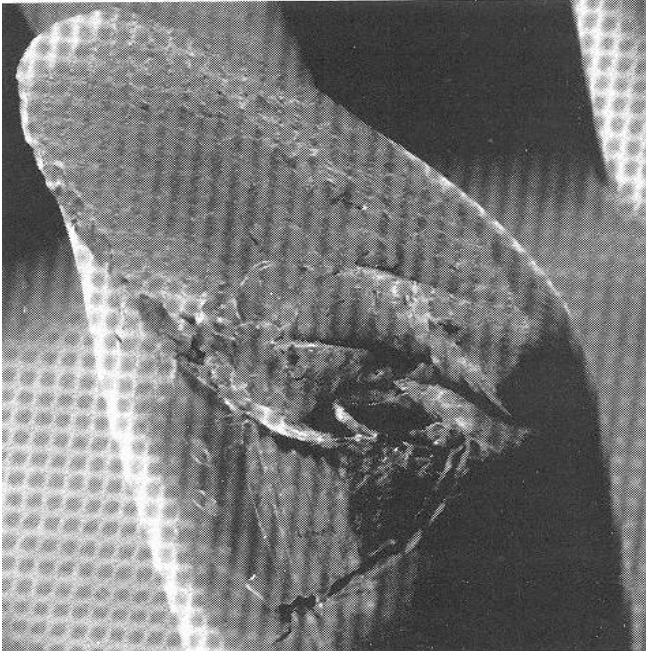
1000X



**Microstructure capstan inclusion microstructure
Grey cast iron, graphite shows found in Rott. Wire, shows
and steatite (eutectic phosphoric) perlite and steatite**

Comparison of microstructures of steel parts used in wire drawing and inclusions found in wire breakage. (Ref. 8)

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UNDER A-CLASS 2
FRACTURE PRODUCED BY INCLUSION
NON-MAGNETIC



of copper oxide inclusion on the fractured surface of the wire breaking

1- CAUSE / E:

2- a great piece of Cu_2O poured and rolled into the wire rod.

Other non-magnetic particles that cause thread breakage are: SiO_2 ; Is C; Al_2O_3 ; Mg O; Yes; and slag.

ORIGINE/I:

1- refractory furnace

2- refractories from adductor channels

3- material from the casting spout

4- accumulations of oxide on the spout

5- particles introduced from office

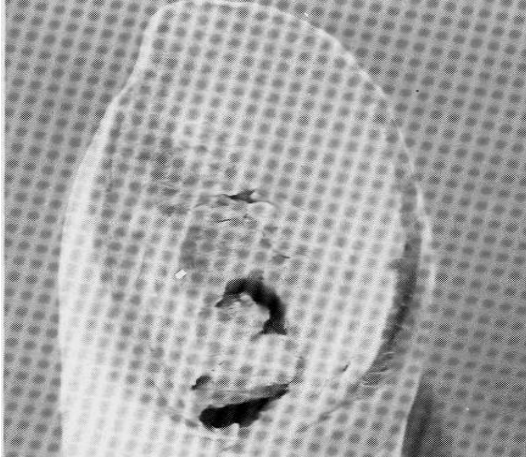
6- copper oxide scratched from the bar of the upper conveyor parts that fall into the liquid copper.

7- copper oxide in the cracks of the bar that are formed in the first steps of rolling.

8- oxide incorporated and particles formed during the preparation

9- Slag trapped during melting and casting.

UNDER CLASS A - 3
FRACTURE INDUCED BY A COMBINATION OF
Inclusions Non-Magnetic and Magnetic



la presenza di inclusioni magnetica (Fe) e non-magnetica (Si)

CAUSA/E:

1- breakage caused by the presence of inclusion non-magnetic (Cu₂O; It; You C; SiO₂, Al₂O₃, Mg O, and slag particles)

3- magnetic particles (iron, steel, iron) in the wire rod.

4- ORIGINE/I:

1- strapping steel or segments of seals introduced during the loading of the cathodes

5- 2- fragments detached from the auction of regulating fluid flow in copper casting

6- of steel wires used to free the outlet of the pouring spout

7- specks of steel from the floor on which vines are scattered, bolts, nuts etc.etc.

8- erosion of orifices output flame gases of the melting furnace burners

9- droplets sprayed away during a welding repair of the oven

10- tiny chips, pagliuzze

and particles that come out from worn rolling rolls or criccati

11- particles d

refractories of the melting furnace

12- particles d

refractory by adduction channels

10- materiale dal beccuccio di colata

11- accumulation of copper oxide on the pouring spout

12- particles introduced by the load operation

13- of copper oxide particles scraped from the solidified bar from upper conveyor that falls inside the casting.

14-oxide particles that are formed in the micro-cracks on the bar in the first steps of rolling.

CLASS V

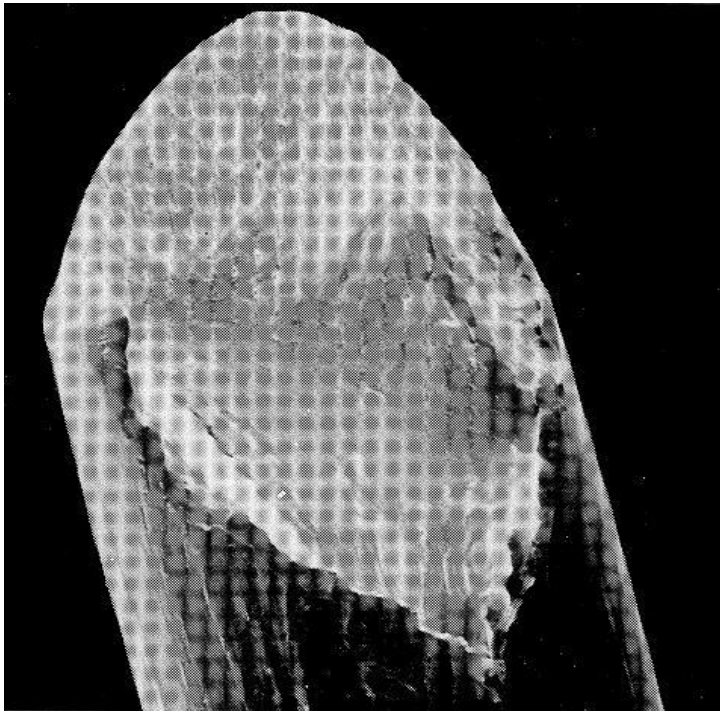
UNDER CLASS B

BREAKING AWAY FROM INCLUSION

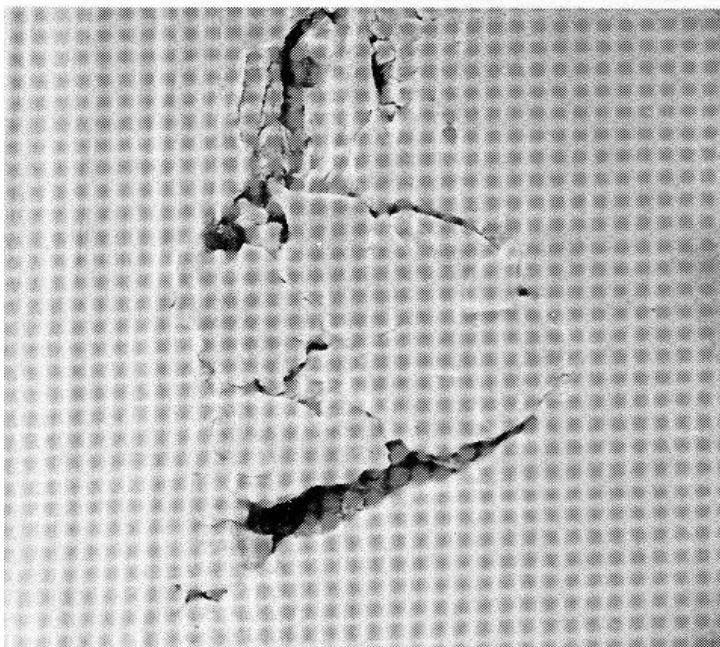
**Other Names: Break That Has Lost The inclusion,
Breaking Up**

With Inclusion Detached; Cava ends; Pressed cavities

the yarn defect characterized by a fracture slit having a shallow cavity on one side. The cavity has been created by an inclusion that is spill during or after the completion of the wire fracture.



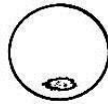
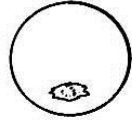
Fracture absent inclusion.



**Inclusion on the wire surface,
away from the main fracture,
was found to contain Iron**

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BROKEN WIRE CAUSED BY microinclusions subcortical
MECHANISM OF THE DEFECT

Transverse View

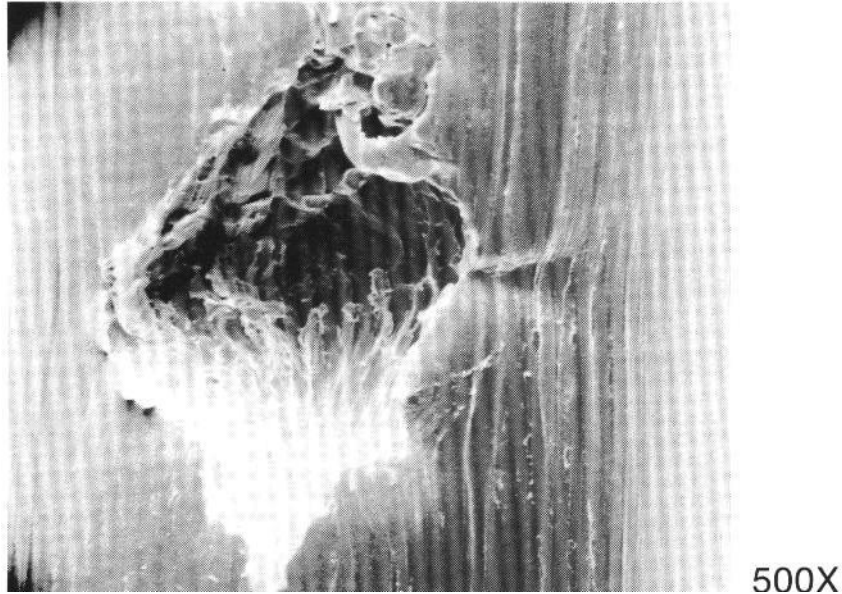


VISTA LATERALE
Side View



**) inclusion (2) successive reductions lead (3) Break
subcortical inclusion in the resulting surface
in wire rod. on the wire**

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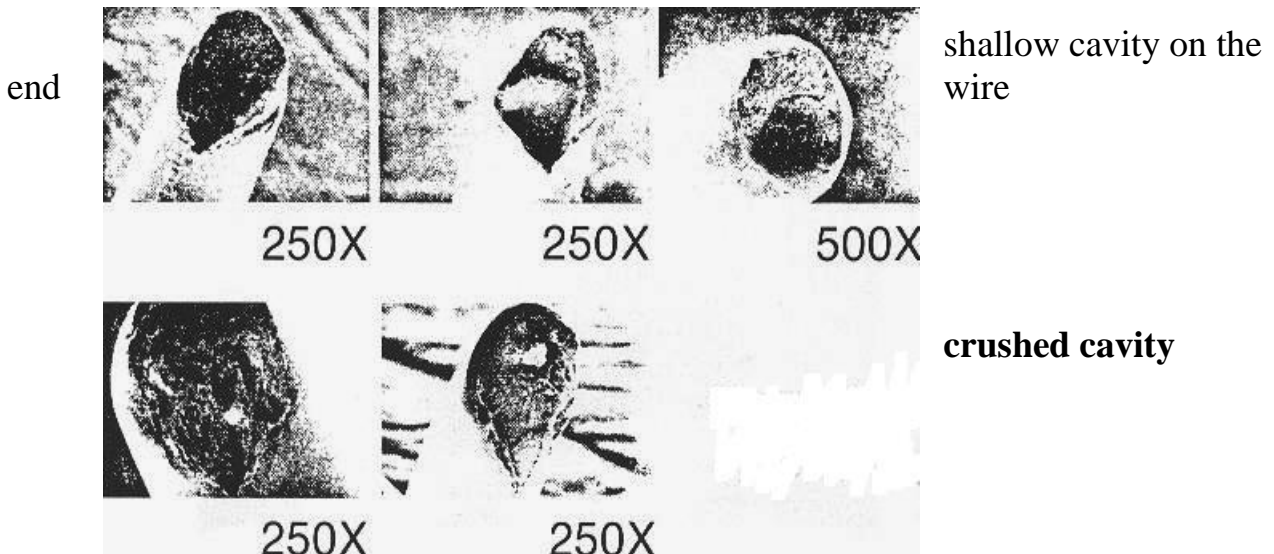
Cavity left by an inclusion that was present on the wire surface. The shape of the cavity on the surface recalls the shape of the fracture.

CAUSA/E:

1-magmatic and non-magnetic inclusions that are present in the wire matrix, damage to the beginning of cracking of the wire drawing process to proceed. The inclusion comes to the surface and breaking comes out and falls in the emulsion, leaving on the surface of the wire its cavity.

ORIGINE/I:

- 1- magmatic inclusions or non-magnetic colored liquid inside the copper and subsequently rolled inside in the copper wire rod**
- 2- inclusions magmatic or non-magmatic incorporated in the process of wire drawing**

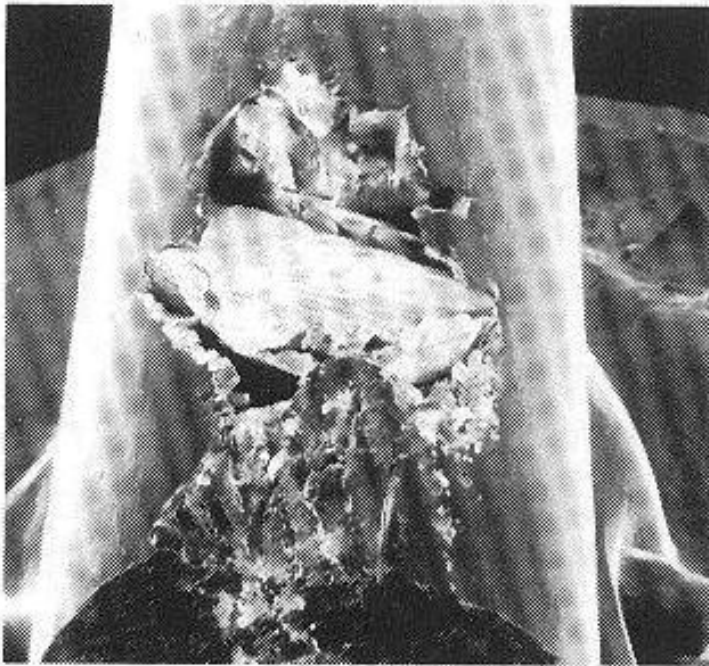


**CLASS V
IN CLASS C**

INCLUSION THIS, incorporated FROM DRAWING

Defects or breakage of the wire characterized by the presence of the inclusion (or from a cavity left by inclusion) on the surface or below the surface of the wire. Foreign particles can be easily introduced below the surface of the

wire during the drawing.
of embedded iron particles under
the surface of the wire.



20X

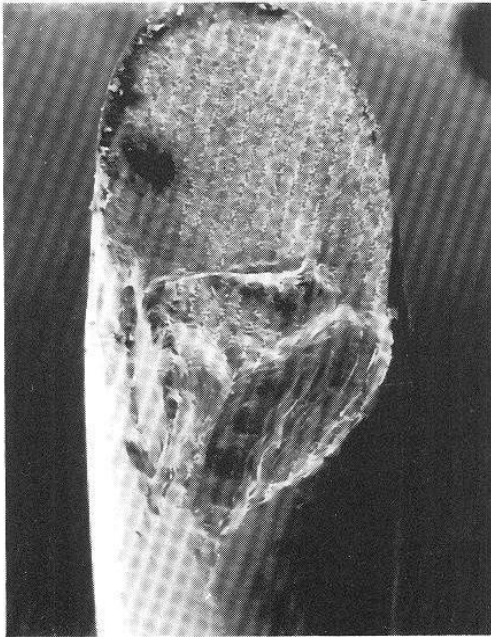
CAUSE / E:

and hard foreign particles, magnetic or non-magnetic, that are present in the chain or in the lubrication-cooler can be stuck on the wire surface so may cause the final breaking of the wire.

- 1- **ORIGIN / I:**
- 2- cooling lubricant containing metal fine particles
- 3- severely worn chains (or chain fragments)
- 3- flecks or tiny flakes coming from the floor
- 4- fragments of wire breakage

CLASS V

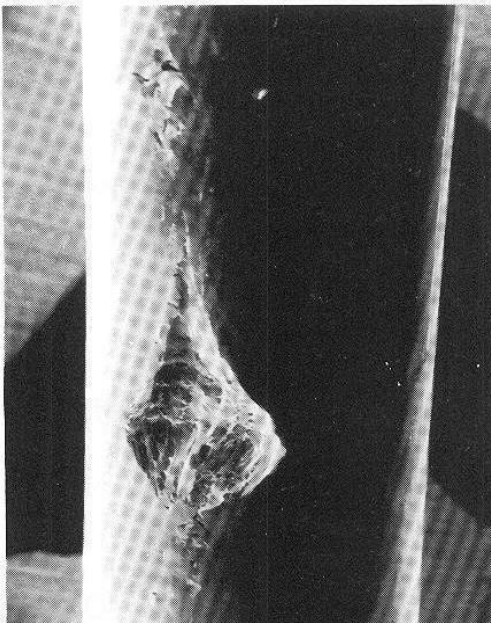
SUB CLASS INCLUSION ABSENT FROM DRAWING



25X

Broken wire characterized by the presence of a depression that was caused by an inclusion. The inclusion was introduced into the surface of the wire during the drawing process.

incision left by a inclusion (in this case one of Fe particle) present on the wire surface.



25X

Engraving left by a inclusion (in this case a particle of Fe) on the wire surface, away from the area where it is fractured.

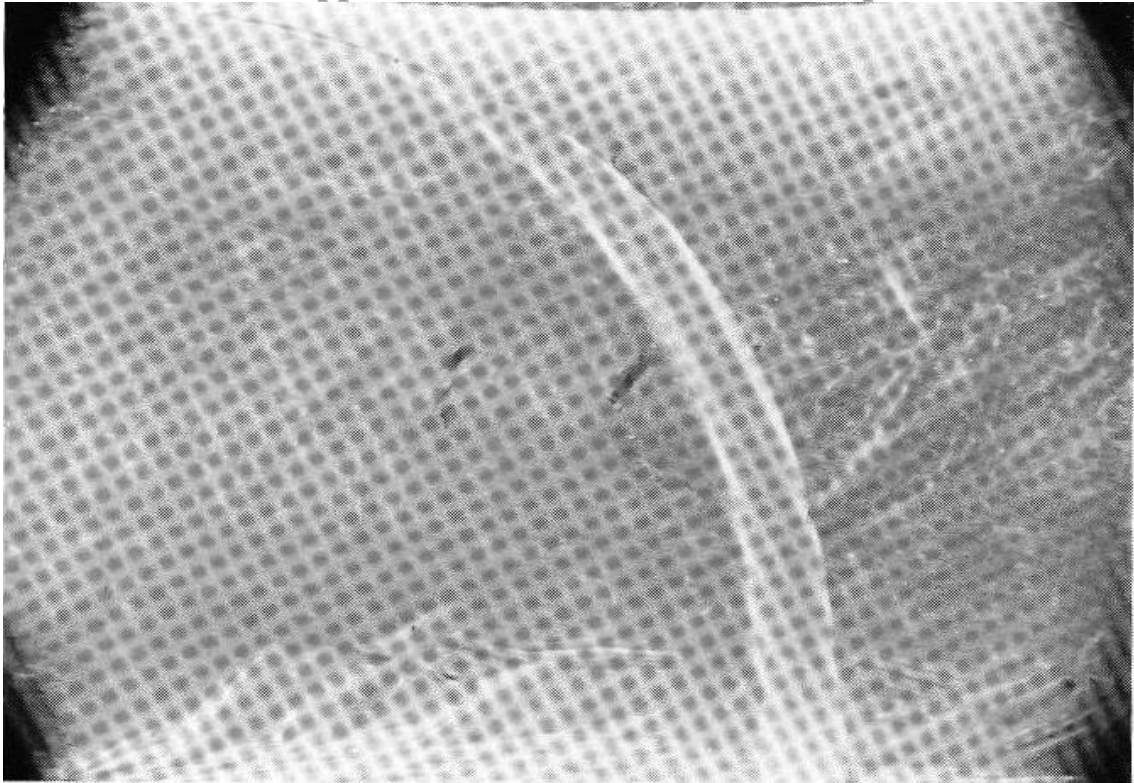
CAUSE / E:

Introduction of Faith particles during the drawing phases.

ORIGINE/I:

- 1- - excessive presence of copper flakes or dust in the lubrication-cooler
- 2- small metallic flakes coming from the floor.

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10X

Imprint or engraving left on the surface of the wire from a twisted steel wire, after it has passed from the first chain (7,34mm).

CAUSE / E:

Foreign objects (ferrous or non-ferrous) introduced on the wire rod or in the lubricant and then drawn into the wire, producing a greater surface defects. The fault will produce a stress concentration during the next steps of drawing that will turn into a thread break.

ORIGIN / I:

ties or bits of twisted wire attached on the surface of the wire rod.

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CLASS VI
BREAKING CAUSED BY kinks
Or Overlays Cross Of Wire

Broken wire characterized by limited ductility and evidence of localized bending combined with twisting (crossed overlapping of the coils wound on the rings), or, by misalignment of the incoming wire in the supply chain.



Rupture associated torsion and bending the wire on the area of fracture

CAUSA/E:

**1- insufficient tension of the yarn turns wound on the capstan or on the cones;
for example: overlapping, curvatures and snags**

2- inadequate lubrication.

3- inadeguate o scorrette Tassi di RIDUZIONE e allungamenti delle filiere.

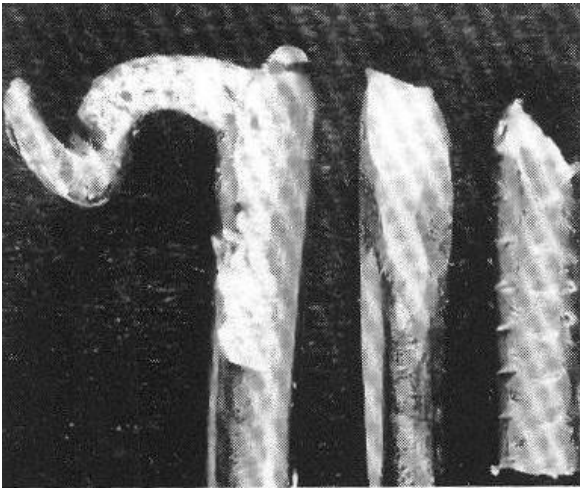
4- ORIGINE/I:

1-cabestani o coni della macchina trafilatrice

3- Sistema di lubrorefrigerazione della trafilatrice.

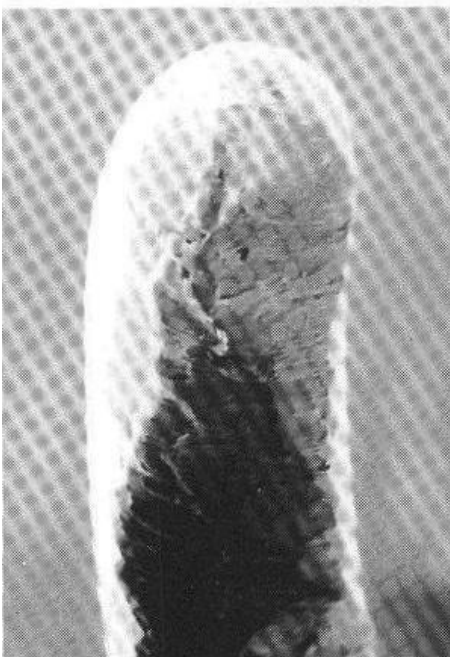
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CLASSE VII
ROTTURE MECCANICHE

Rotture filo Che Si manifestano un Seguito di danneggiamenti Meccanici.
Le rotture meccaniche mostrano evidenti tracce di intagli, Di Segni, di scavature, di eccessiva abrasione, di Profondi graffi.



1X

abrasion damage observed in the vicinity of the wire breaking



69X

from abrasion damage observed in the vicinity of the wire breaking

CAUSE / E:Rupture caused by the capstan of the drawing machine which has abraded the wire in the

phase of rapid deceleration stop caused by thread breakage.

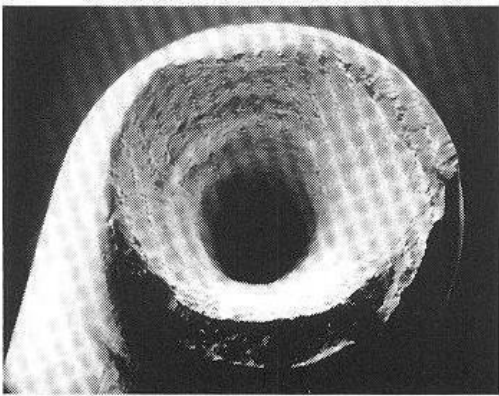
ORIGIN / I:

Capstan / s of the drawing machine.

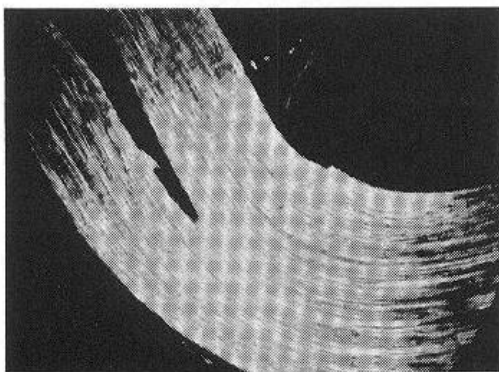
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CLASS VIII - microporous'

Other Names: End With cavity; Crush cavity (Pressed)

Fracture characterized by a deep cavity, similar to a depression to "funnel". The inner walls of the funnel-shaped cavity appear to be smooth and free from contamination or from particles. The empty cavity, can also continue for several millimeters over the surface of the fracture. The portion "male" of the "soul" of the cavity, however, does not extend to the end of the female portion.



SEM micrograph of a thread break for macro porosity that exhibits the characteristic funnel-shaped cavity.



30X

optical micrograph of a longitudinal section showing the central cavity that extends inside the second flow of material.

10X

CAUSA/E:

Empty previously located in the center of the wire. They can be formed during the casting, rather than by an excessive presence of dissolved gas in the liquid copper or contraction by solidification in the center of the casting bar.

ORIGINE/I:

1-excessive presence of gas (hydrogen) in the molten metal

2- solidification contraction at the center of the bar.

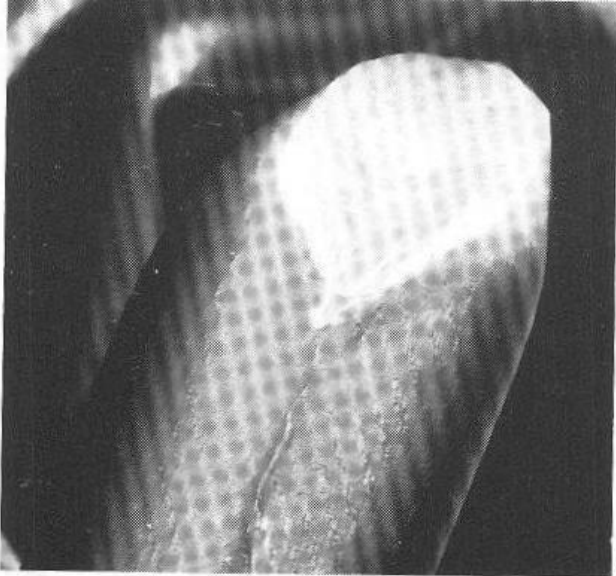
4- fluctuation of the liquid level in the tundish copper casting, as

5- result of this, it will be possible to have a "unhealthy" bar, that is, with portions that have the central cavity (empty).

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CLASS IX

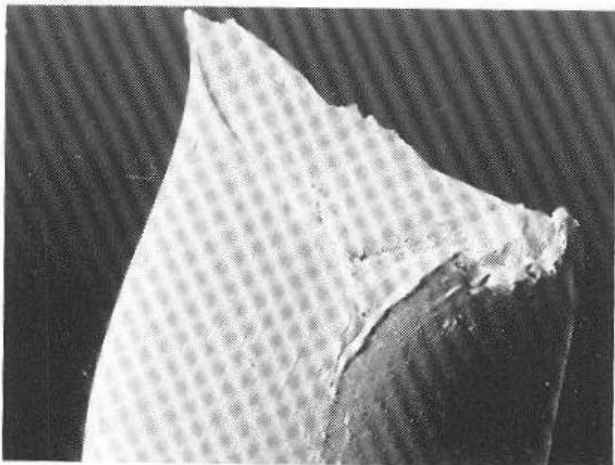
BURR AND SCAGLIA incorporated into ROLLING

thread breakage characterized by the existence of bavette or cracks in the break. Burrs or the cliques may contain oxide or even to contain it.



31X

Breakage associated with a defect of hot-rolling of the wire rod.



20X

wire breakage associated with a burr on the wire rod.

CAUSA/E:

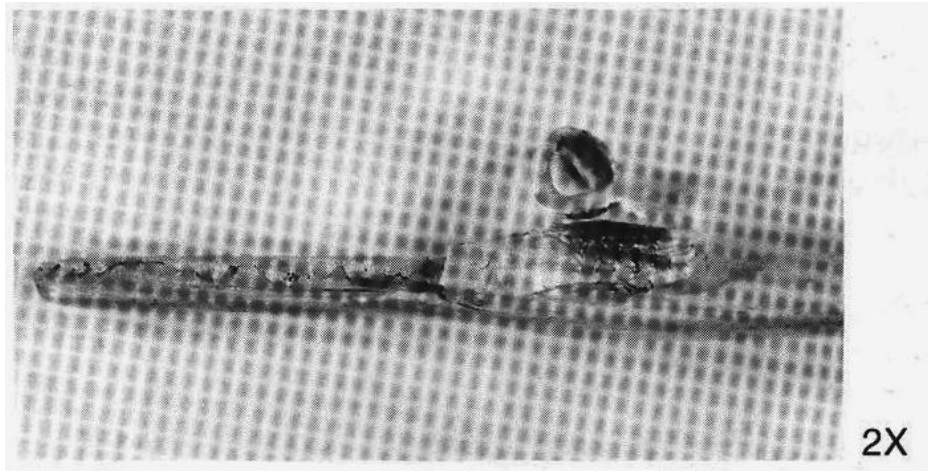
- 1-intrusion of rolling scale
- 2-clique longitudinal

ORIGINE/I:

- 1-intrusion of rolling scale
- 2-presence of a longitudinal crack (the bar is ciccata during the hot rolling.
- 4- of longitudinal rolling line (overfilled) on the wire rod, caused by an inappropriate parting of the rolling rolls ..

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CLASS A
SPLINTER

Defect characterized by "a piece of metal bent" ("traced") on the structure of the thread.

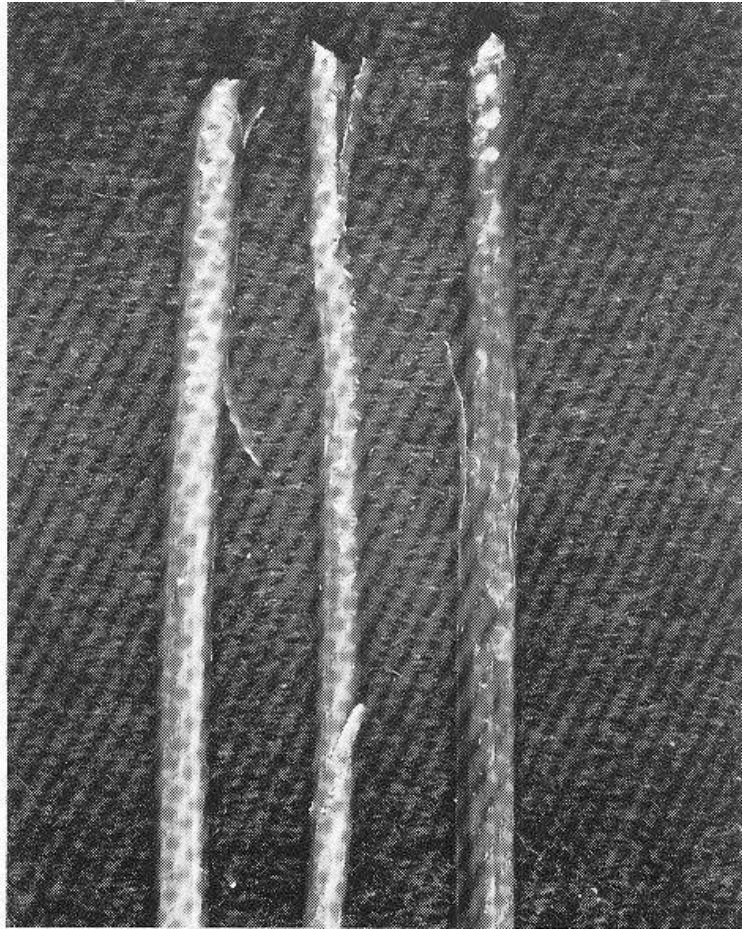


The chip performs the "characteristics of a folded piece of metal"; this is the result of a longitudinal row (or "swaging") of rolling (overfills).



This splinter formation is apparently due to problems encountered during mechanical drawing.

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2X

Broken wire showing splinters (caricatures) on the wire surface, where the breakage occurred.

CAUSA/E:

- 1- mechanical damage**
- 2- damage during wire rod rolling**
- 3- longitudinal rows (overfilled) that have been incorporated in the wire rod during the hot rolling.**

ORIGINE/I:

- 1- - surface defects on the wire rod**
- 2- mechanical handling**
- 3- longitudinal rows (overfilled) during the rolling**

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CLASS

Break With End split

Broken wire characterized by a large crack or split (splitting)

coming from a clique located in the center line of the wire.

CAUSA/E:

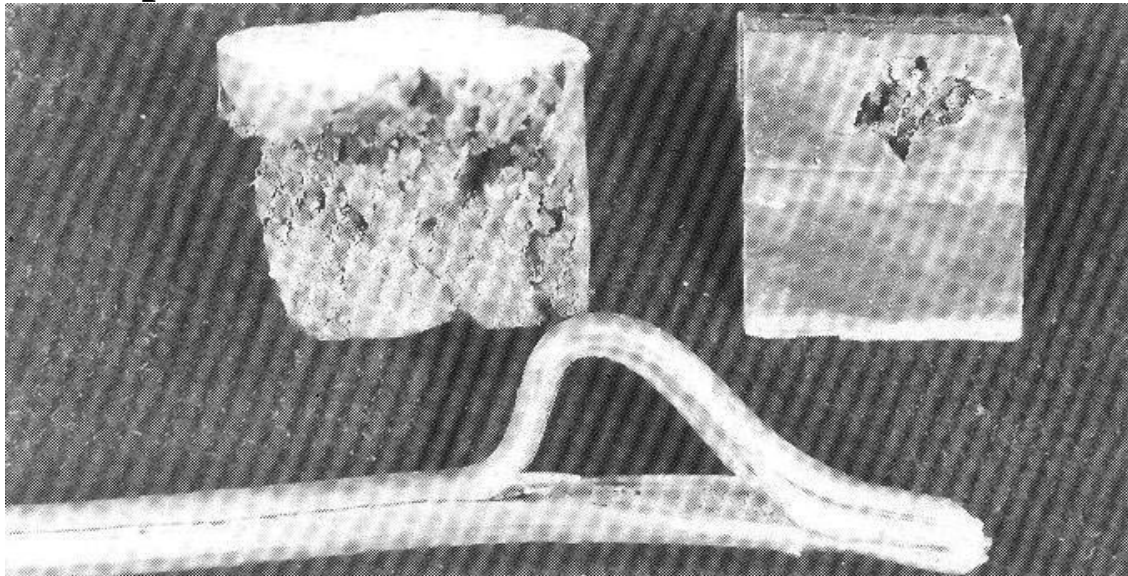
- 1- strong dunks cavities
- 2- deformed cracking in the cast bar
- 3- presence of a strong layer of copper oxides in the center of the wire rod.
- 4- presence of a foreign substance in the wire rod.
- 5- flakes incorporated in the wire rod during the rolling steps.

ORIGINE/I:

- 1- cracking in the bar during the steps of laminations
- 2- copper slag introduced during the casting operation.
- 3- - extraneous substances introduced during casting or before the start of rolling.
 - Flakes of oxidized copper from tools that thread milling edges of the bar before it enters the mill.

CLASS XI
SUB CLASS A

Split ends WIRE CAUSED BY SLAG OF OXIDE

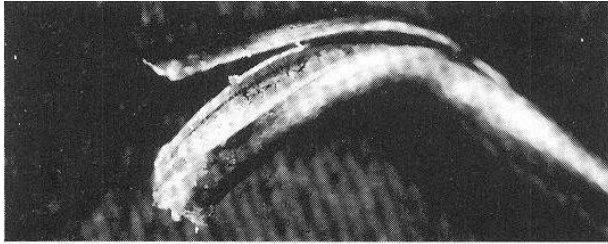


Presence of a slag of coarse copper oxide in the fracture area.

CASE / E: presence of a slag of coarse copper oxide in the cast bar that has been enclosed by the lamination.

ORIGIN / I: copper oxide slag introduced during casting of the bar.

**CLASS XI
UNDER CLASS B
WIRE SPLIT BECAUSE OF SEGREGATION
COPPER OXIDE**



1X

CASE / E: high concentration of

the copper oxide particles in the cast bar which have remained poorly distributed in a wire rod with fragile strings of oxides.

SORGENTE/I:

1-flakes of oxide particles falls in the molten copper in the wheel groove.

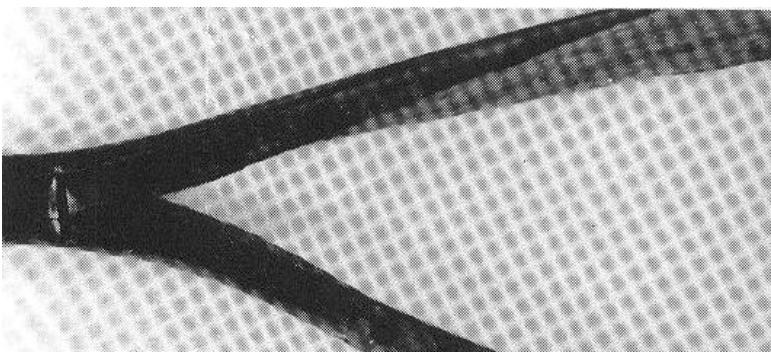
2-oxide particles formed on the pouring spout, which have fallen into the underlying liquid copper.

Clusters of oxides of copper around the orifices of the burners falls in the metal.

Irregular distribution of copper oxides in the matrix, caused by incorrect cooling of the wheel.

IN CLASS C

**Splitter WIRE DUE TO ALIEN SUBSTANCES
(Refractory Material Del coating) THE WIRE ROD.**



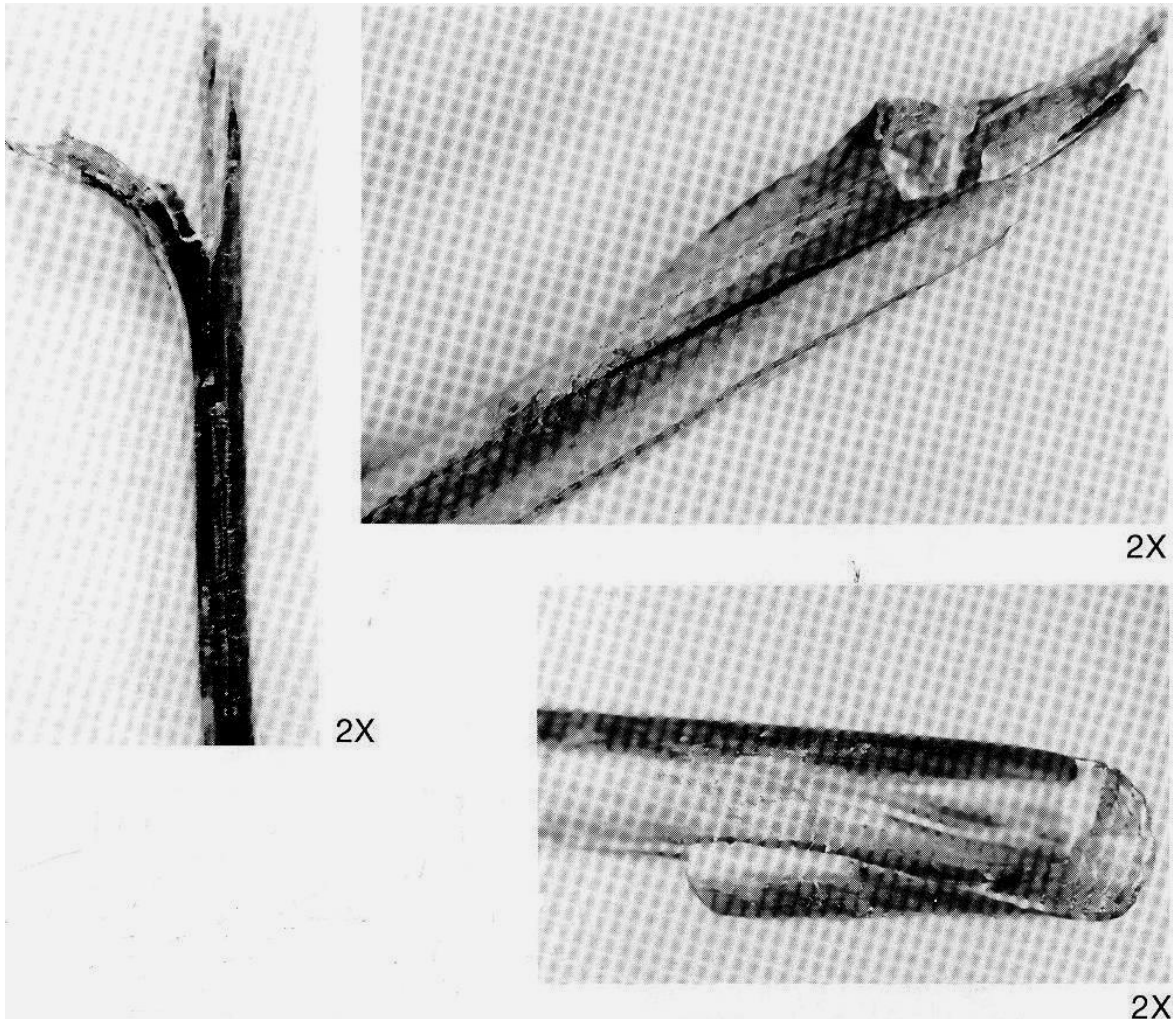
1X

Macro photography of split end which shows the presence, in the fracture zone, of a refractory coating.

CAUSE / E: introduction of a foreign substance during casting or before lamination.

ORIGIN / I: presence of a refractory coating in the casting phase.

CLASS XI
SUB CLASS D
Split ends CAUSED BY SCAGLIE incorporated BY
ROLLING



Macro showing
different ways to present
fracture due to flakes
incorporated by laminating
hot wire rod

CAUSE / ED: entrapment of chips in the bar prior to lamination.

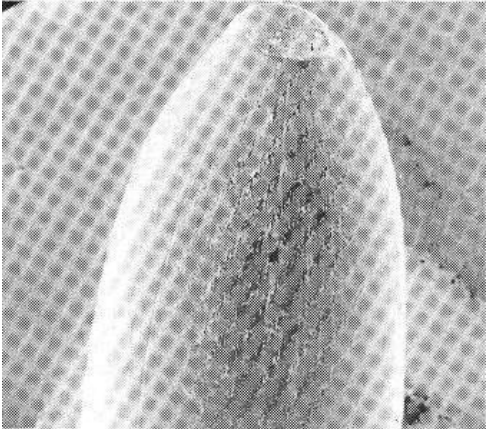
ORIGINE/I:

burrs of oxidized copper remained attached on the bar,
falls on it in the area of the bevel of the upper edges, by
means of the cutting tools.



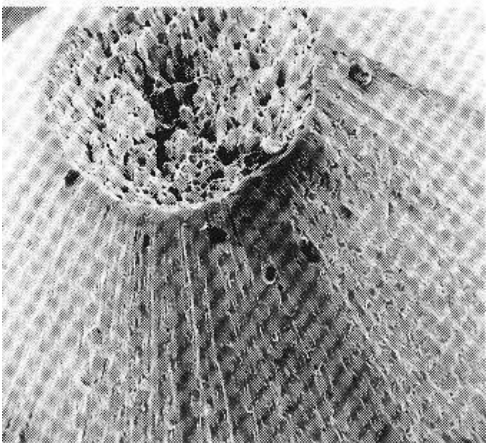
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CLASS XII
FRACTURE FOR TRACTION

Broken wire characterized by a significant reduction of the section (Neck-down) of the wire and small craters on the surface where took place the fracture. The break for necking occurs when the wire drawing effort exceeds the value of the tensile strength on wire.



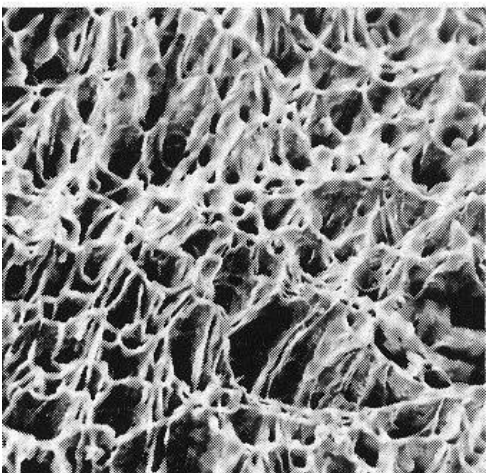
20X

Micrograph electronic scanning of a type of failure by necking showing the characteristics of "the two cups" and the symmetry of the break in the necking area.



60X

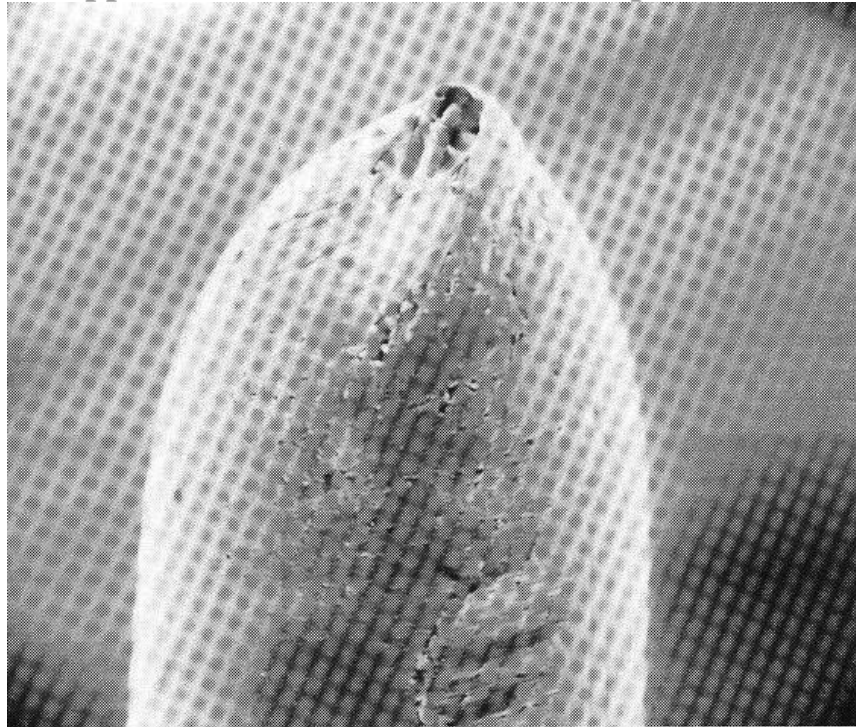
SEM micrograph of a tensile failure showing the formation of "craters" on the fracture surface.



200X

Fractography SEM of a thread break for necking showing the characteristic micro-voids with the peripheral walls lengthened indicating the ductility of copper ETP1.

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255X

Copper Exempt From Oxygen (Oxygen Free Copper)

CAUSA/E:

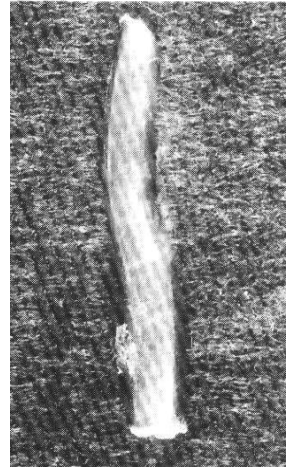
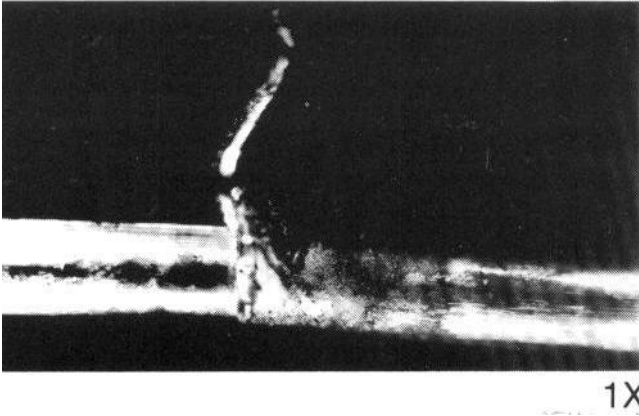
- 1- unsuitable chain or unusual wear chains
- 2- sliding of incorrect wire on the surface of the capstans, due to wear or to an insufficient number of windings around it.
- 3- Capstan having the wrong diameter
- 4- Errata of the die geometry, too small reduction corner, or cylindrical part, the wire calibration hole, too long.
- 5- emulsion too dirty drawing that favors the entrance of dirt training in supply chain and artificially creates a smaller wire diameter.
- 6- Overlap of the wire on the capstan, due alla'eccessiva of surface wear, or too many turns of wire wrapped around it.
- 7- Rip induced on the edge of the improper operation of the machine.
- 8- Excessive copper powder particles

ORIGINE/I:

equipment of the drawing machine and / or practical experience in drawing.

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**CLASS III
SUB CLASS A
ANGLE CHAIN**



CAUSE / E: misalignment

chain and the supply chain.

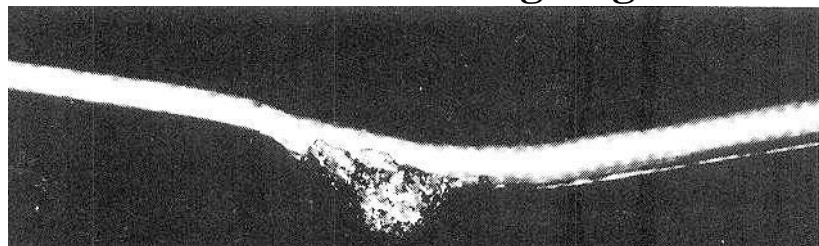
ORIGIN / I: door chain and chain

60X

the door

**CLASS III
SUB CLASS B - BROKEN WIRE DUE TO THE CHAIN
STOPPERED.**

**Other Names: Broken Wire Caused From Copper "Plated"
The Cone of Farming Login**



CAUSA/E:

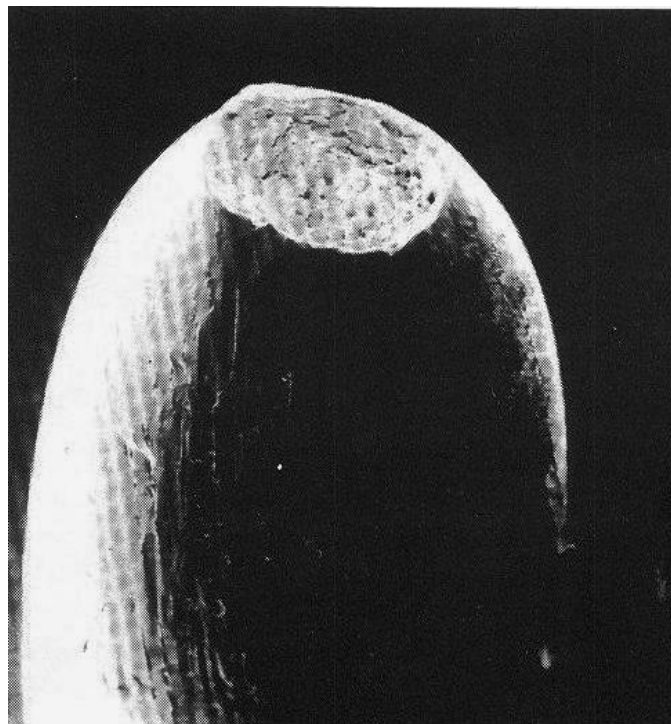
- 1- tension caused by metal stuck on the wire rod in the car entry
- 2- Excessive emulsion copper powder
- 3- entry angle and reduction not perfectly coupled.
- 4- no direct emulsion spray good toward entry cone of the supply chain.

ORIGINE/I:

- 1- poor maintenance of cooling lubricant
- 2- the chain geometry

CLASS XII
IN CLASS C
FRACTURE FOR TRACTION DUE TO OVERRIDE THE
CROSS OF SPIRE ring CAPSTAN

yarn breakage produced by the second coil on the ring of the capstan, lying in superimposed and crossed on the previous, creating a clamping of the wire and consequently a voltage associated with a deep scraping on the adjacent surfaces of the wire turns.



tensile failure caused by overlapping cross (crossover) of the wire ring of the capstan

CAUSA/E:

- 1-inappropriate or wrong scale chains reduction.**
- 2-ring wear of the capstan with engravings.**
- 3-misalignment between the die and the capstan.**

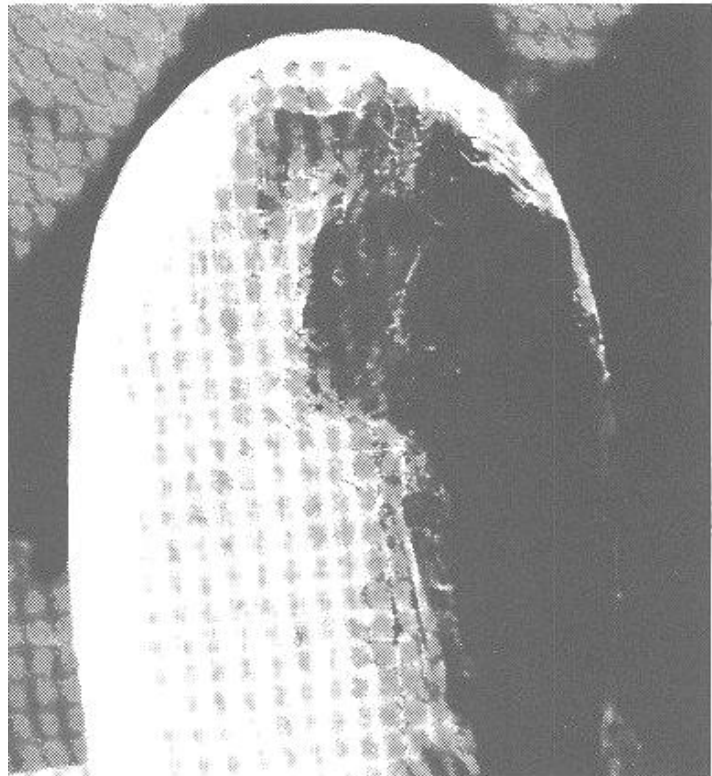
ORIGINE/I:

- 1-chains**
- 2-capstan ring.**
- 3-door chain.**
- 4-practical experience of drawing.**

CLASS III
SUB CLASS D
FRACTURE FOR TRACTION DUE TO BAD TRANSFER
(HANDLING)

thread breakage produced by the rod that was not handled properly in the movement of the deflector in the skein change phase.

**Tensile failure produced by
poor transfer and / or
handling**



45X

CAUSA/E:

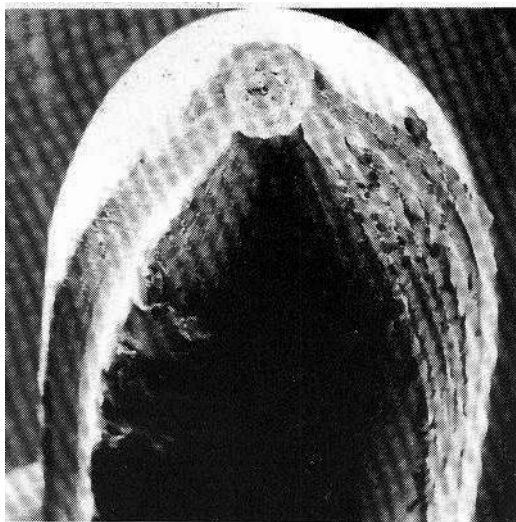
- 1-shifting plate or wire transfer, damaged.
- 2- wire rod reel holder deformed or badly damaged
- 3- wrong adjustment of rod movement speed gearbox
- Inappropriate 4-tension wire rod during the change

ORIGINE/I:

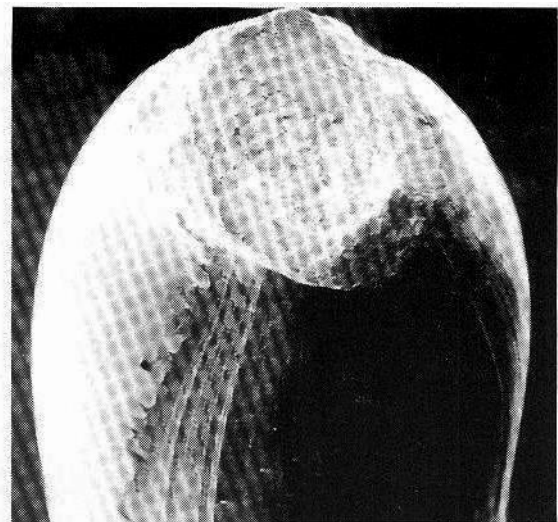
- 1-plate rod displacement
- 2-door wire rod coils
- 3 battery system for wire rod exchange

CLASS III
SUB CLASS E
FRACTURE FOR TRACTION DUE TO SEVERE WEAR
CHAIN

thread breakage due to worn chain, hard particles introduced into the chain, poor lubrication, improper scale reduction chains, supply chains built or adjusted wrong, incorrect chain alignment, emulsion temperature much higher than normal ..



30X



30X

Fractures traction due to a very severe die wear.

CAUSA/E

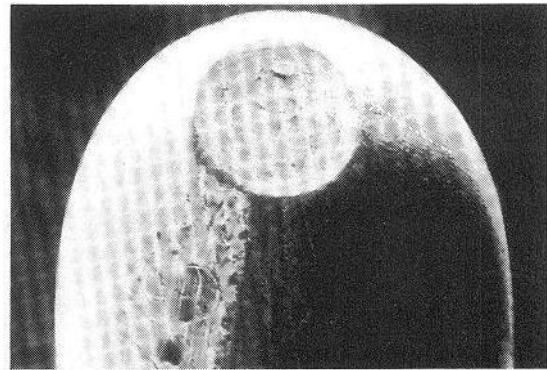
- 1- worn chain.
- 2- hard particles in the supply chain
- 3- insufficient lubrication
- 4- chains of incorrect reduction scale.
- 5- wrong geometry in the construction sectors
- 6- misalignment chain
- 7- lubrication-cooler too much warmer than normal.

ORIGINE/I

- 1-too high chain length of the cylindrical section, calibration diameter
- 2-worn chains
- 3-too high surface defects on the wire rod.
- 4-over- or under reduction
- 5-collar incoming wear to the chain, not rectified.

CLASS III
SUB CLASS F
THREAD CAUSED BY PLASTIC ANNODATA ALONG

yarn breakage produced by growths of insulating material dal'estrusore, who created nodes of insulating material on the wire, which is jammed in the guides or in the ceramic thread guiding rings, causing tension on the thread.



40X

wire breakage caused
from a material node
insulating

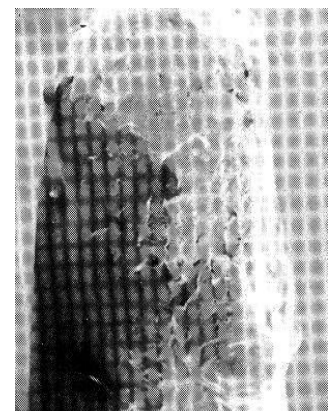
CASE / E: welding a piece of insulating the extruder caused by a malfunction or by an improper relationship between the speed of the extruder screw and the line.

ORIGIN / I: Extruder

CLASS III
SUB CLASS G

To break Traction Due To Burn (Merger Of Wire) In Oven

Broken wire produced by an electrical discharge or by too high a temperature set for the lehr. For necking rupture caused by a burn in the oven



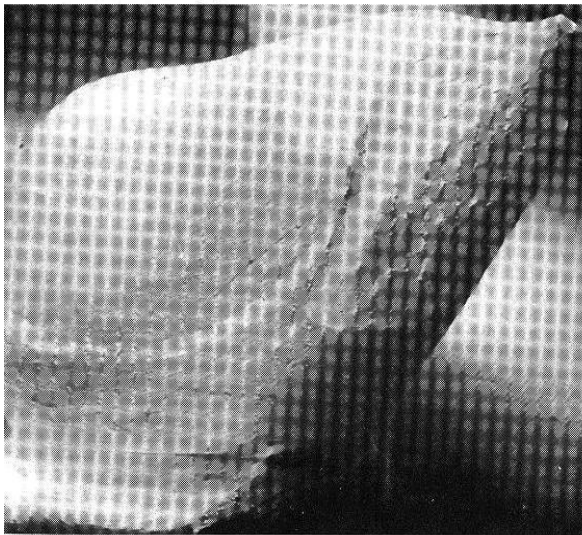
CAUSA/E:

- 1-discharge of an electric arc in the oven
- 2-incorrect electrical voltage in the oven
- 3-band of excessively dirty contact
- 4-band excessively grooved wear contact
- 5-incorrect adjustment of the speed between the drawing machine and the oven.
- 6-wrong voltage or high temperature furnace
- 7-speed different between the two pulleys of the oven.

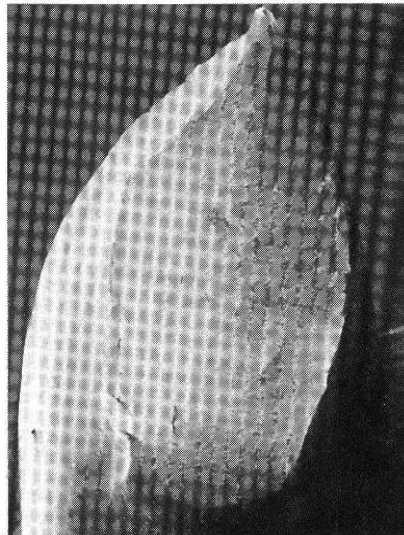
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CLASS XIII

FAILURE TO TANGLE (BARE)

yarn breakage that occurs when two or more coils of wire rod skein tangle together forming a node outside of the drawing machine. This type of breakage resembles a cutting fracture.

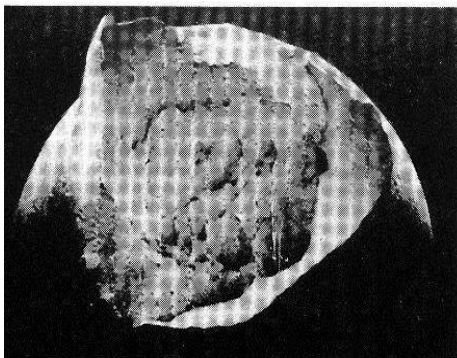


9X



11X

**Typical
breakdown
due to tangle
on the
incoming
wire rod.**



13X

CAUSA/E:

- 1- Deposition inadequate spiral wire rod
- 2- wrong or inadequate handling of the wire rod coils.

ORIGINE/I:

1-coil system of continuous casting which carries the deposition spiral wire rod.

2-manual or mechanical handling of the wire rod coils
unfit

CLASS XIV

TEARS OF WELDING (electric)

the yarn defect characterized by the formation of cracks that have the form of the type "fish mouth", of flat rupture (or fragile) and necking. Usually this type of fracture takes place during the early stages of drawing

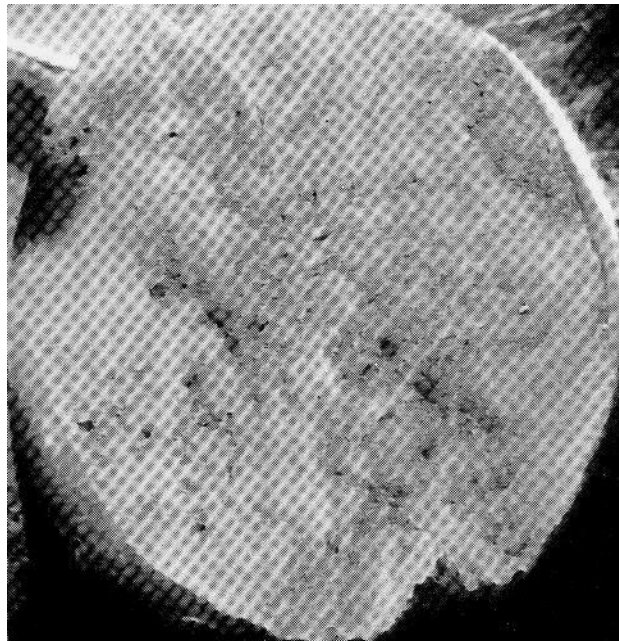
CLASS XIV

UNDER CLASS A

BREAKING "FLAT" WELDING FROM ("Power")

Break produced in the welding area which exhibits a plate boundary.

This defect is characterized by a low ductility in the area of the fracture.



Flat" rupture of a weld ("Power")

CAUSA/E:

WRONG WELDING ("Power") OF WIRE ROD

- 1-incorrect setting of the heating power (too high or too low)**
- 2-wrong preparation of the two ends to be welded.**
- 3-incorrect removal of burrs formed during welding**
- 4-end welding wire rod too "harsh"**

ORIGINE/I:

machine for electric welding and / or inadequate technique of operations.

**CLASS III
SUB CLASS B**

FRACTURE OF THE TYPE "FISH MOUTH"

Fracture "V" currently present when the cutting forces acting on the area of weakened welding, which has been originated from the clique within the welding

Fracture to "fish mouth"

CAUSA/E:

WRONG WELDING

("Power")

THE ROD

1 setting-wrong

temperature

(Too high or too low)

2-wrong preparation

ends to be welded.

3-incorrect removal of welding burrs.

4-ends to be welded, wire rod too "harsh"

ORIGINE/I

Macchina saldatrice e/o operazioni inadeguate.

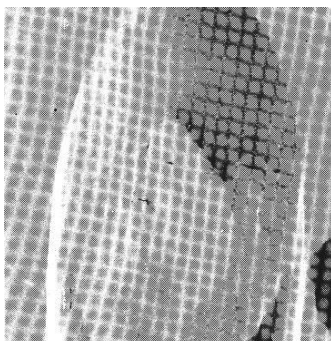


12X

**CLASS III
SUB CLASS C**

FRACTURE CUTTING

It breaking characterized by an inclined fracture of 45 ° which elapses from one part of the wire. Normally, there are no interruptions in the inclination of the fracture. The cutting forces are the main cause of the spread and affect the area weakened by welding.



12X

IDEM

Shear fracture on welding

CAUSE / Errata temperature (too high and / or too low)

-Errata End preparation.

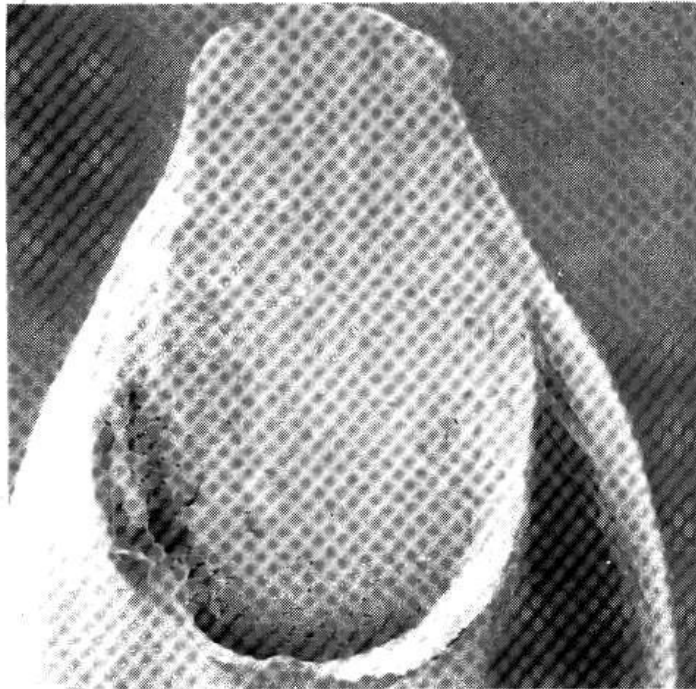
Incorrect removal of burrs

Ends of wire rod too "harsh"

ORIGIN / I: welding equipment and / or practical experience

CLASS III
SUB CLASS OF
FRACTURE FOR TRACTION WELDING

yarn breakage that was manifested in the welding zone and is characterized by a necking at that point. The structure of the material in the area of the weld is normally ductile, but contains micro-voids or internal defects that give beginning to fracture.



lettrica)

35X

CAUSA/E:

INCORRECT OR IMPROPER WELDING THE WIRE ROD

- 1- incorrect temperature (too high and / or too low 9*
- 2- wrong end preparation to be welded*
- 3- incorrect removal of welding burrs.*
- 4- End of wire rod too "harsh"*

ORIGINE/I:

welding apparatus and / or practical experience

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