INTRODUCTION

- Cast iron is the name given to those ferrous metals containing more than 1.7% carbon.
- Cast irons like steels, are basically alloys of iron and carbon.
- Cast irons contain more than 2 percent carbon.
- Most commercially manufactured types are in the range of 2.5 to 4 percent carbon.


CAST IRON SKILLET


ASTM-888 CAST IRON PIP

COMPOSITION

- All cast irons contain more than 2% C.
- Cast iron is the alloy of carbon with 1.7 to 4.5% carbon and 0.5 to 3% silicon.
- But in some alloy it has Manganese 0.5 to 1.0%, Phosphorous 0.1 to 0.9 %, & Sulphur 0.07 to 0.10%.

STRUCTURE

- It have a matrix structure which may be established either during cooling from the molten state (as cast condition) or as a result of heat treatment. The main component of cast iron are Iron, carbon, silicon.

TYPES OF CAST IRON

- The best method of classifying cast iron is according to metallographic structure.
- There are four variables to be considered which lead to the different types of cast iron.
- Some variables may control the condition of the carbon and also its physical form.
- The types of cast iron are as follows:

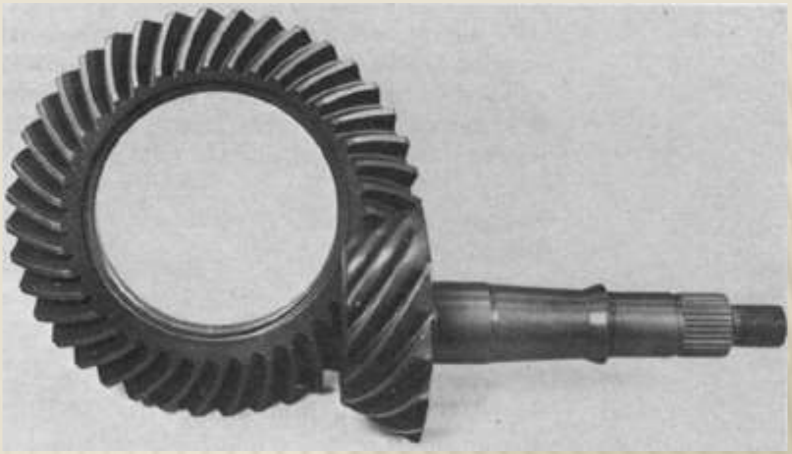
1. White Cast Iron

2. Malleable Cast Iron

3. Gray Cast Iron

4. Chilled Cast Iron

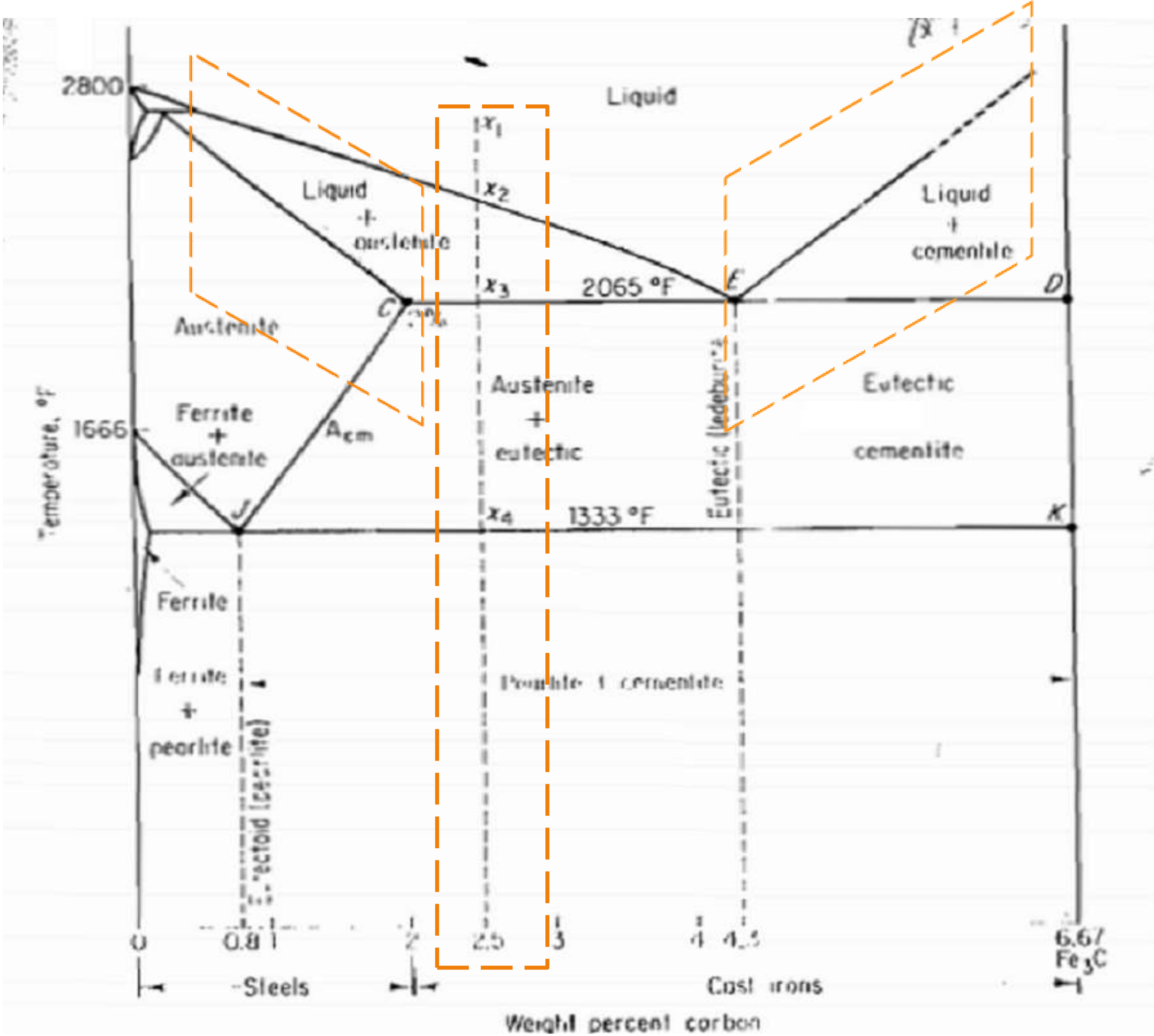
5. Nodular Cast Iron



6. Alloy Cast Iron

1. WHITE CAST IRON

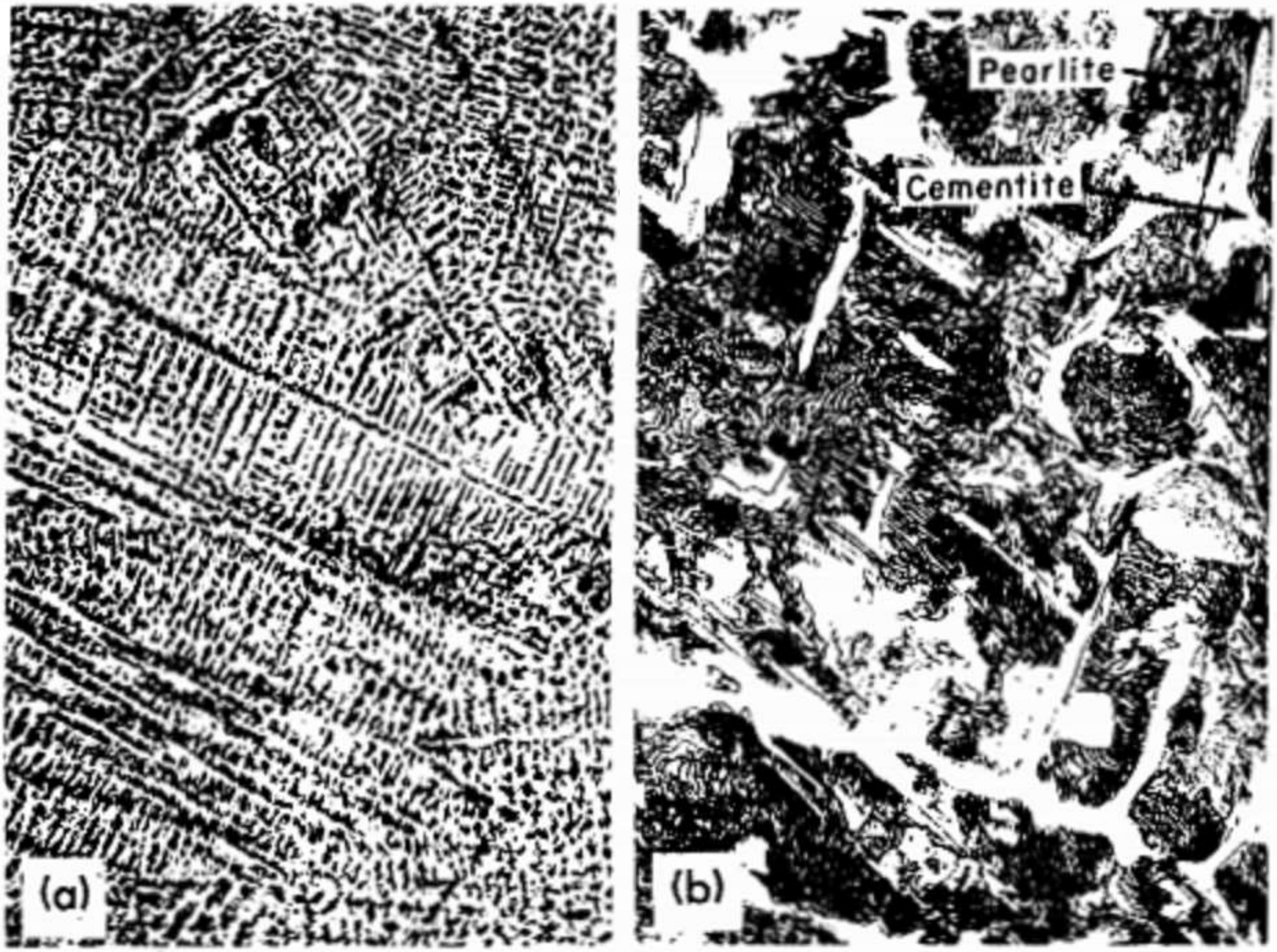
- It is the cast iron in which all the cast iron in the combined form as cementite.
- All white cast iron are hypoeutectic.
- In the figure the alloy at “x” exists as a uniform liquid solution of carbon dissolved in liquid iron.
- Solidification now begins by the formation of austenite crystals containing about 1 percent carbon.


Liquid
2800
Liquid
+
austenite
Liquid
+
cementite
2065 °F
C
E
D
Austenite
Austenite
+
eutectic
Eutectic (ledeburite)
Eutectic
cementite
1666
Ferrite
+
austenite
A_{cm}
J
1333 °F
K
Ferrite
Ferrite
+
pearlite
Pearlite + cementite
x_1
x_2
x_3
x_4
Temperature, °F
0
0.8
2
2.5
3
4
4.3
6.67
Fe_3C
Steels
Cast irons
Weight percent carbon

1. WHITE CAST IRON

STRUCTURE:

- The typical microstructure of white cast iron, consisting of dendrites of transformed austenite (pearlite) in a white interdendritic network of cementite, Higher magnification of the same sample reveals that the dark areas are pearlite.


Pearlite
Cementite
(a)
(b)

1. WHITE CAST IRON

PROPERTIES:

- It is hard, brittle & interstitial compound.
- Due to large amount of cementite it is hard & brittle but extremely brittle & difficult to machine
- The range mechanical properties for unalloyed white irons is as follows: hardness Brinell 375 to 600, tensile strength 20,000 to 70,000 psi, compressive strength 200,000 lo 250,000 psi and modulus of elasticity 24 to 28 million psi.

1. WHITE CAST IRON

APPLICATION:

It can be used as liners of cement mixers, ball mills, drawing dies and extrusion nozzles.

NOZZLE

BALL MILLS

CEMENT MIXERS

2. MALLEABLE CAST IRON

INTRODUCTION:

- It is the cast iron in which most or all of the carbon is uncombined in the form of irregular round particles known as temper carbon.
- This is obtained by heat treatment of white cast iron.

2. MALLEABLE CAST IRON

MANUFACTURING:

- White irons suitable for conversion to malleable iron are of the following range of composition:
- Carbon → 2.00-2.65%
- Silicon → 0.90-1.40%
- Manganese → 0.25-0.55%
- Phosphorous → Less than 0.18%
- Sulphur → 0.05%

2. MALLEABLE CAST IRON

- Commercially, It can be prepared by two steps:

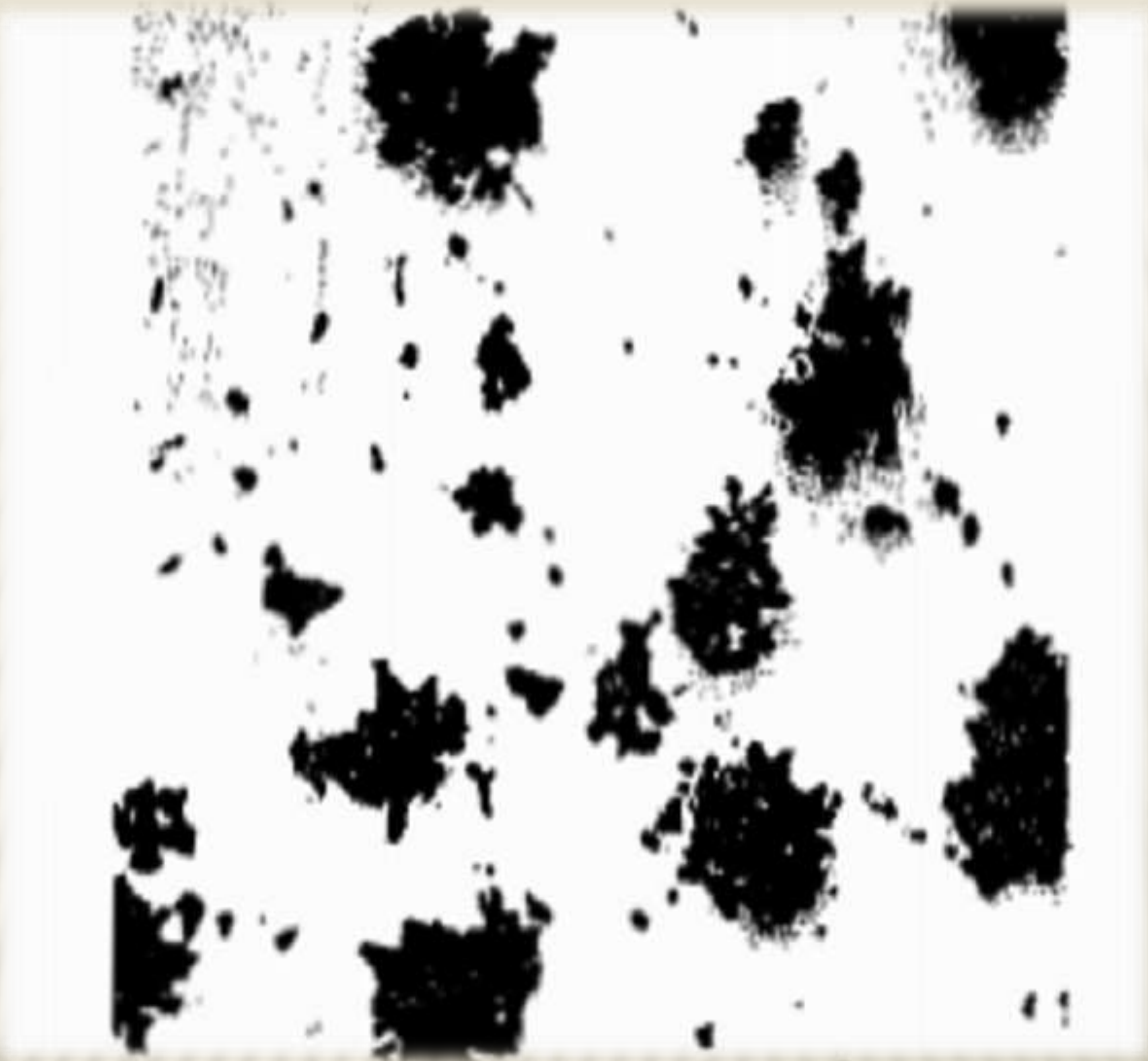
  (1) First stage annealing.

  (2) Second stage annealing.

- In the first-stage annealing, the white-iron casting is slowly reheated to a temperature between 1650 °F and 1750 °F.
- This graphitization starts at the malleableizing temperature.

2. MALLEABLE CAST IRON

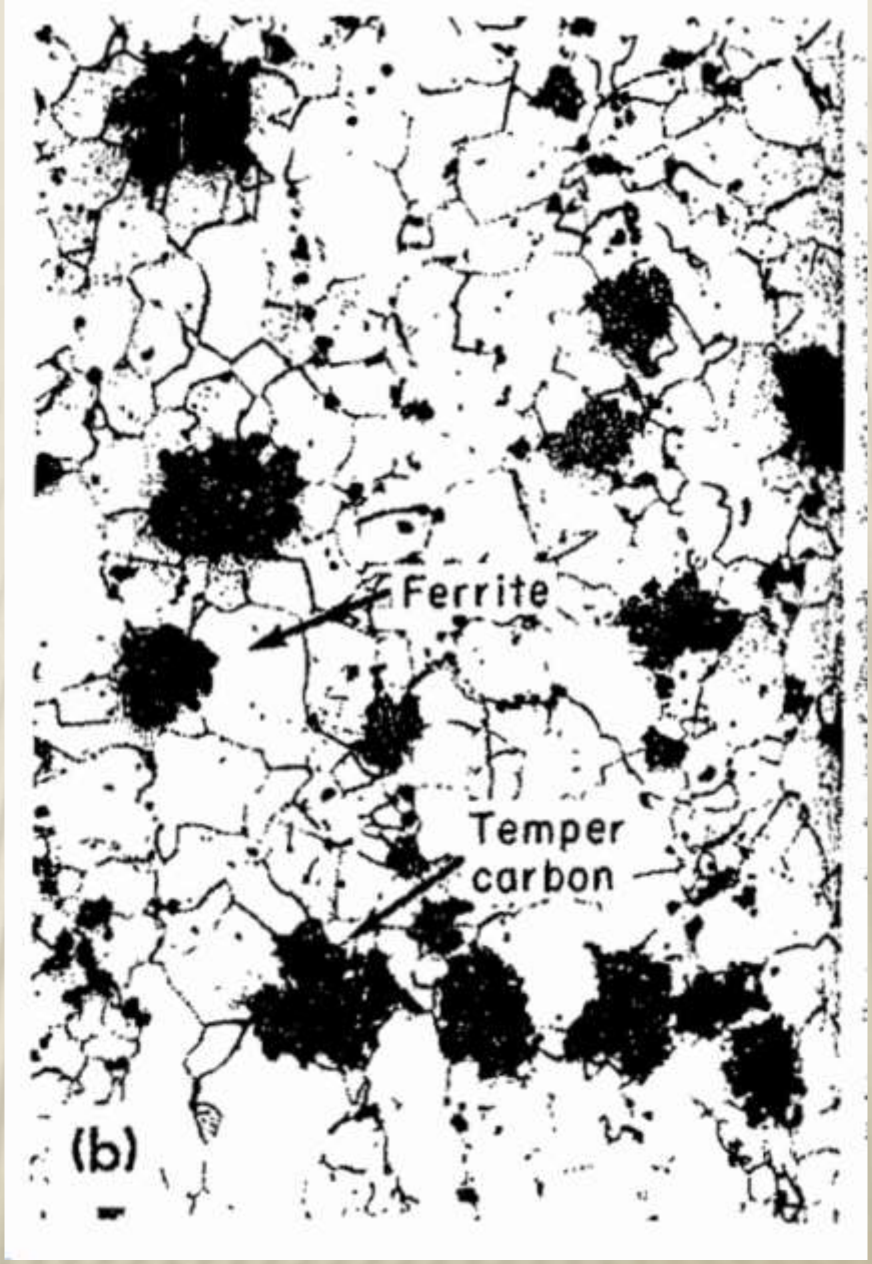
- The initial precipitation of a graphite nucleus depletes the austenite of carbon, and so more is dissolved from the adjacent cementite.
- The graphite nuclei grow at approximately equal rates in all directions and ultimately appear as irregular nodules or spheroids usually called temper carbon. As shown in figure.



MALLEABLE IRON, UNETCHED. IRREGULAR NODULES OF GRAPHITE CALLED TEMPER CARBON. (100X)

2. MALLEABLE CAST IRON

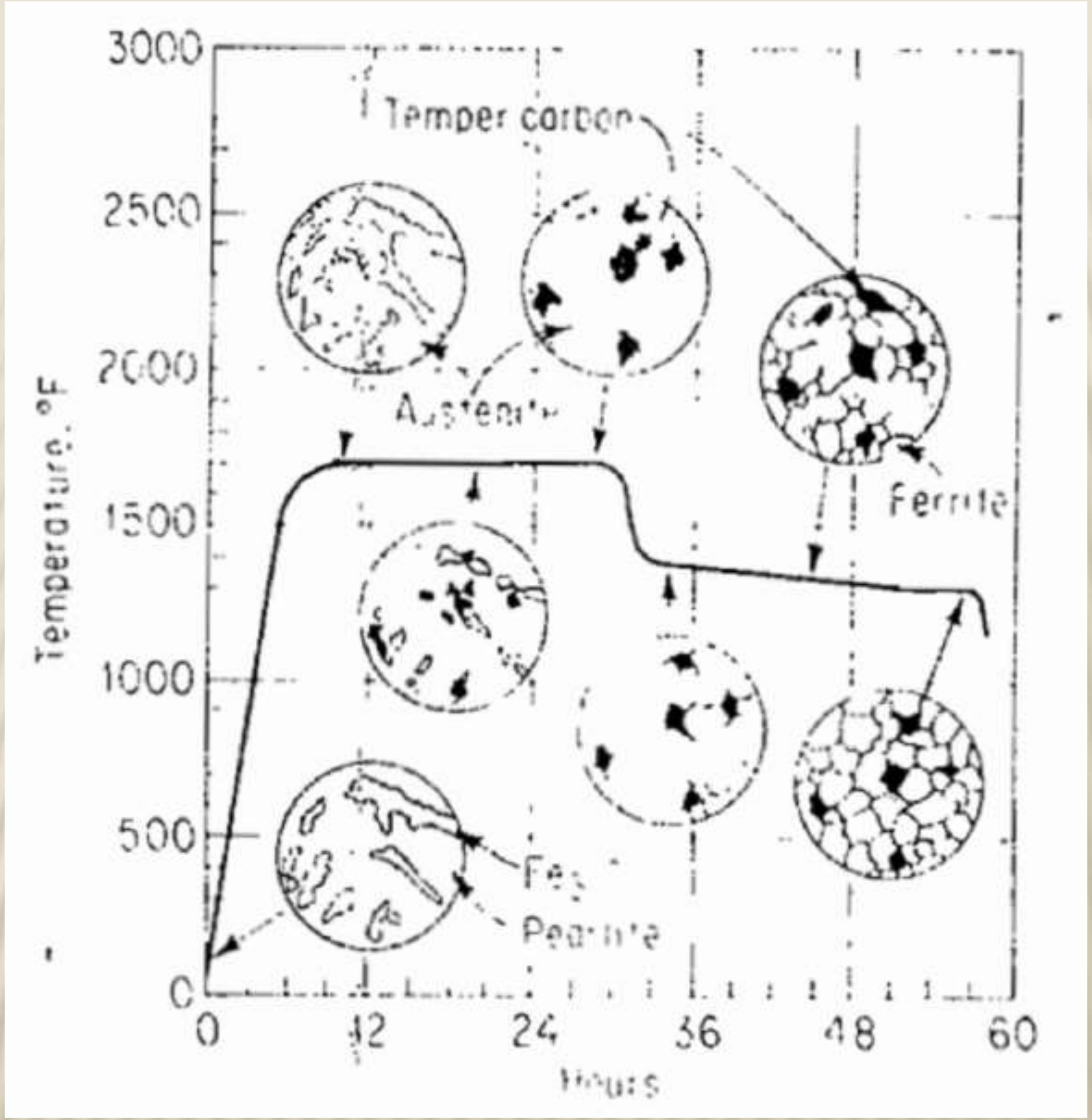
- After first-stage annealing, the castings are cooled as rapidly as practical to about 1400oF in preparation for the second stage of the annealing treatment.
- During the slow cooling, the carbon dissolved in the austenite is converted to graphite on the existing temper-carbon particles, and the remaining austenite transforms into ferrite. After cooling to room temperature the structure is known as standard malleable cast iron.



Ferritic malleable iron, temper carbon (black) in a ferrite matrix. Etched in 5 percent nital, 100x,

2. MALLEABLE CAST IRON

- The changes in microstructure during the malleableizing cycle are shown schematically in Figure.



The changes in microstructure as a function of the malleableizing cycle-resulting in temper carbon in a ferrite matrix'

2. MALLEABLE CAST IRON

PROPERTIES:

- When copper is added it increase its tensile strength, corrosion resistance e.t.c.
- The properties of malleable cast iron are:

  1. Tensile Strength → 58000-65000 (psi)
  2. Yield point → 40000-450000 (psi)
  3. Elongation % in 2 in →15-20
  4. BHN → 135-155.

2. MALLEABLE CAST IRON:

APPLICATION:

It can be widely used as:

- Pipe fittings.

- Chain-hoist assemblies.

- Railroad equipment.
- Also as industrial casters e.t.c.

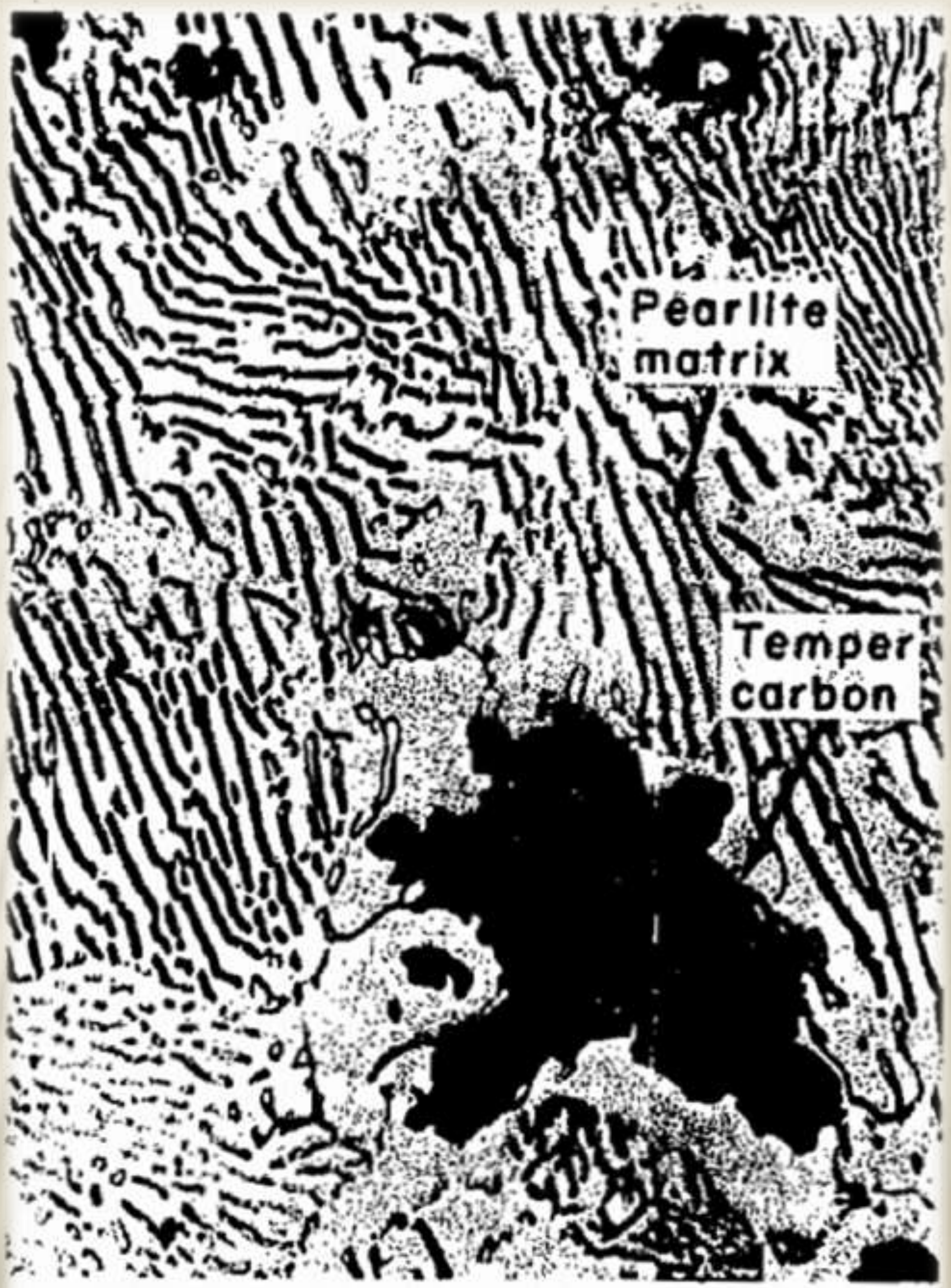
3. PEARLITIC MALLEABLE CAST IRON

- If a controlled quantity of carbon, in the order of 0.3 to 0.9 percent, is retained as finely distributed iron carbide, an entirely different set of mechanical properties results.

- If manganese is added, the regular \ cycle can be maintained to retain combined carbon throughout the matrix.

- The second-stage annealing of the normal process may be replaced by, a quench, usually air, which cools the casting through the eutectoid range; fast enough to retain combined carbon throughout the matrix.

- The matrix is completely pearlitic shown in figure.



Pearlitic malleable iron. Nital etch, 500×.

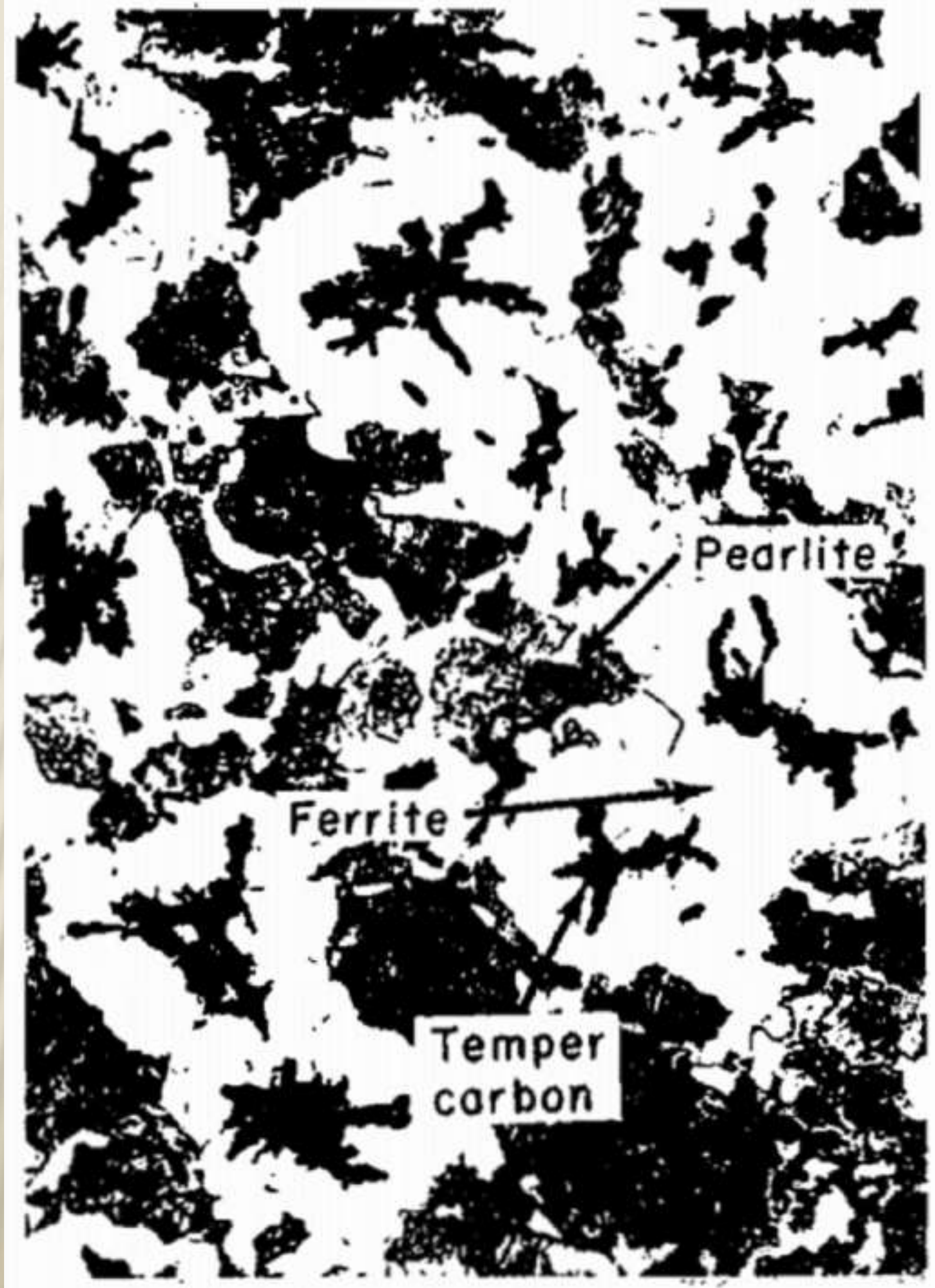
MATRIX OF PEARLITIC MALLEABLE IRON

Pearlitic malleable iron. Nital etch, 500x.

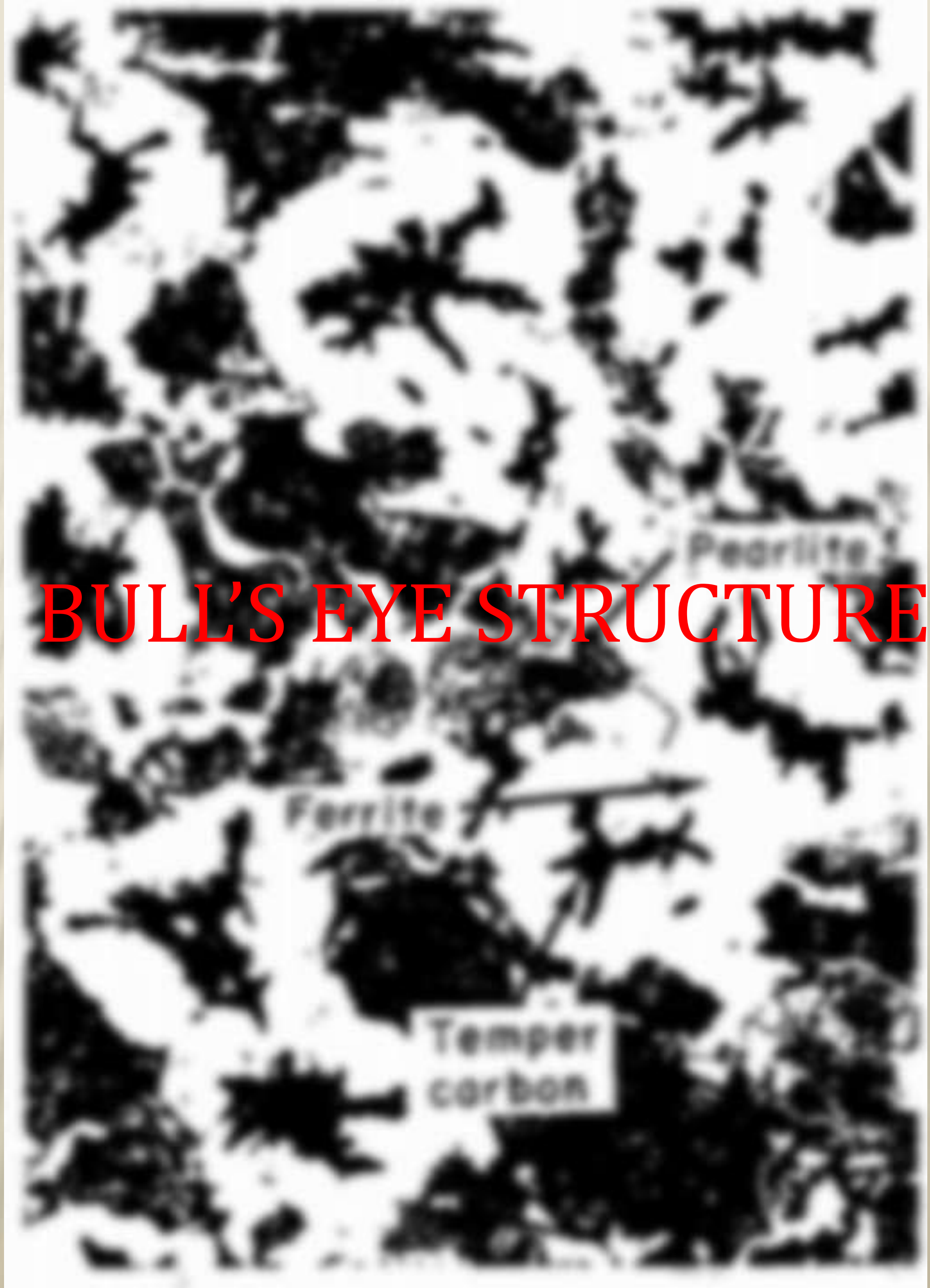
3. PEARLITIC MALLEABLE CAST IRON

If the cooling rate through the critical range is not quite fast enough to retain all the combined carbon, the areas surrounding the temper-carbon nodules will be completely graphitized, while those at greater distance from the nodules will be pearlitic .

Because of its general appearance, this is referred to as a **bull's-eye structure**. As shown in figure.


Pearlite
Ferrite
Temper carbon

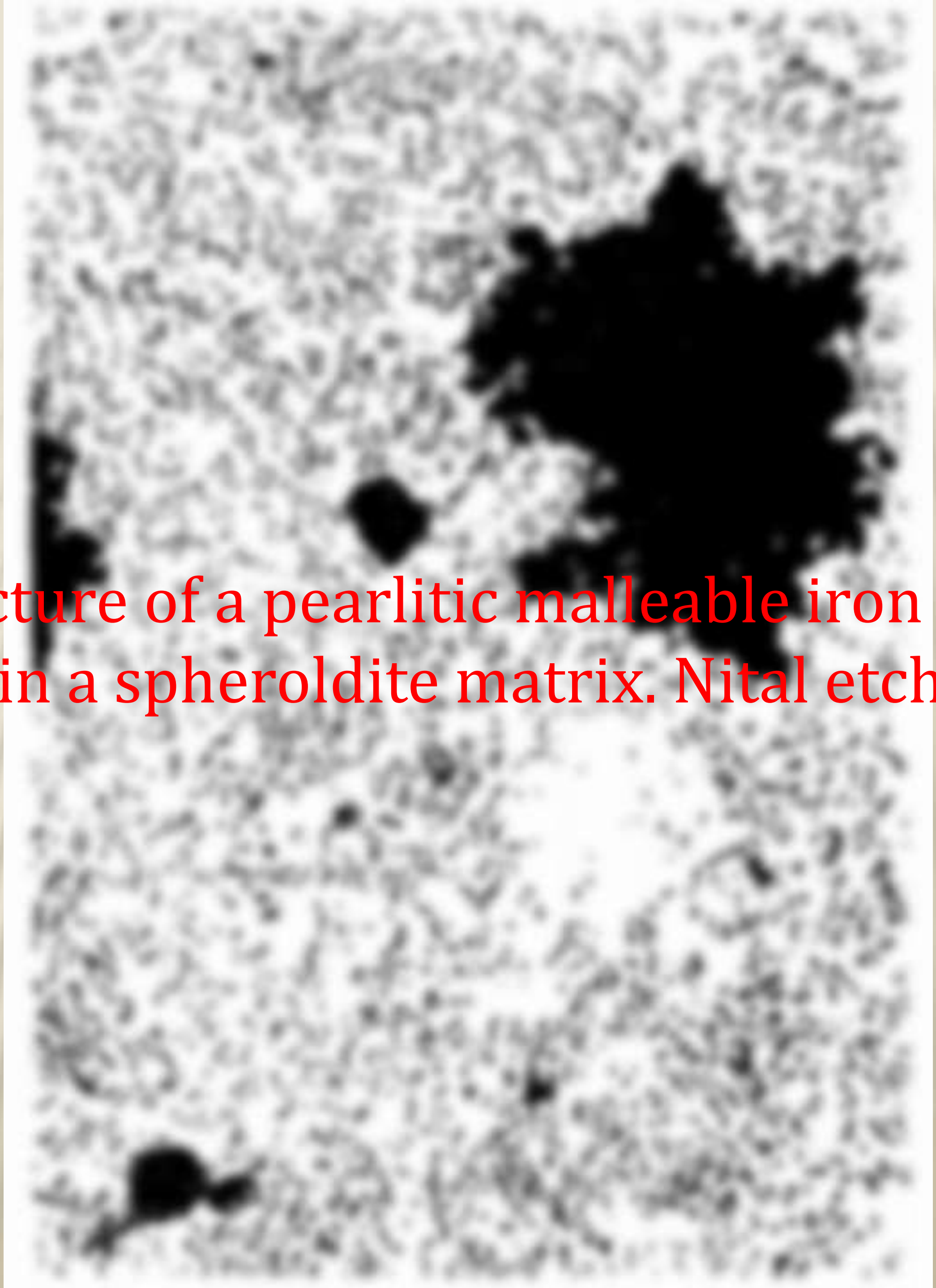
BULL'S EYE STRUCTURE



3. PEARLITIC MALLEABLE CAST IRON

PROPERTIES:

- We can also add some alloying element like Manganese, sulphur & copper. Copper may be added to increase corrosion resistance & graphite distribution.
- If it is heated at 1200F to 1300F it improves its machineability, toughness & lower the hardness. The spheroidize the pearlite as shown in figure.



Microstructure of a pearlitic malleable iron tempered to obtain a spheroldite matrix. Nital etch, 500x

3.PEARLITIC MALLEABLE CAST IRON

APPLICATION:

- It can widely used in industries application like:
- Camshafts and crankshafts in automobiles
- Rolls, pumps, nozzles, cams, and rocker arms as machine parts.
- For a variety of small tools such as wrenches, hammers, clamps, and shears.

CAMSHAFT


CAMSHAFT


CAMSHAFT

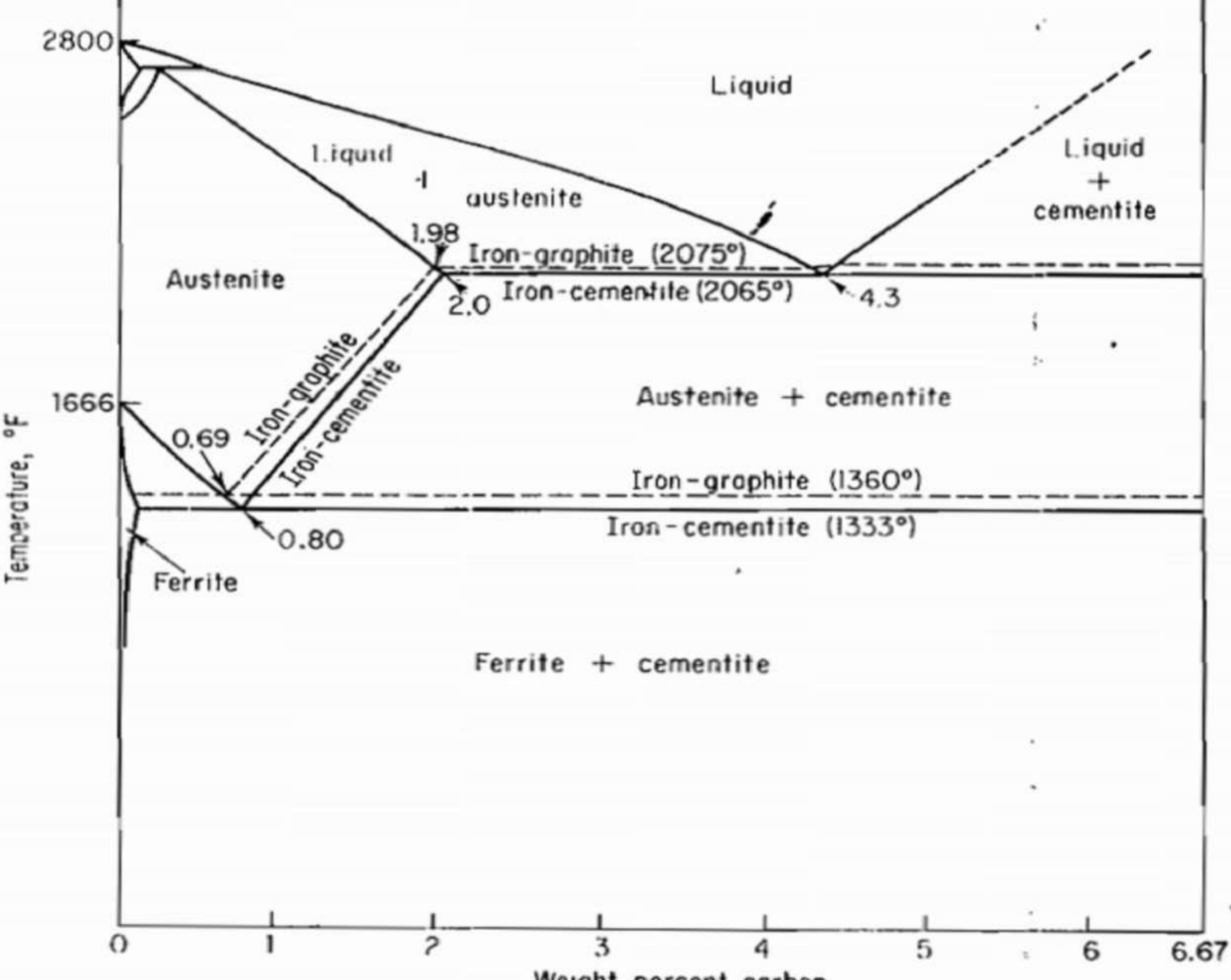

CRANKSHAFT

4. GRAY CAST IRON

- It is the cast iron in which most or all of the carbon is uncombined in the form of graphite flakes.

- Most gray cast irons are hypoeutectic alloys containing between 2.5 and 4 percent carbon.
- The initial appearance of combined carbon is in the cementite resulting from the eutectic reaction at 2065F<.

- There is experimental evidence that, with proper control of the alloying element, the alloy will follow the stable iron-graphite equilibrium diagram,), forming austenite and graphite at the eutectic temperature of 2075F.

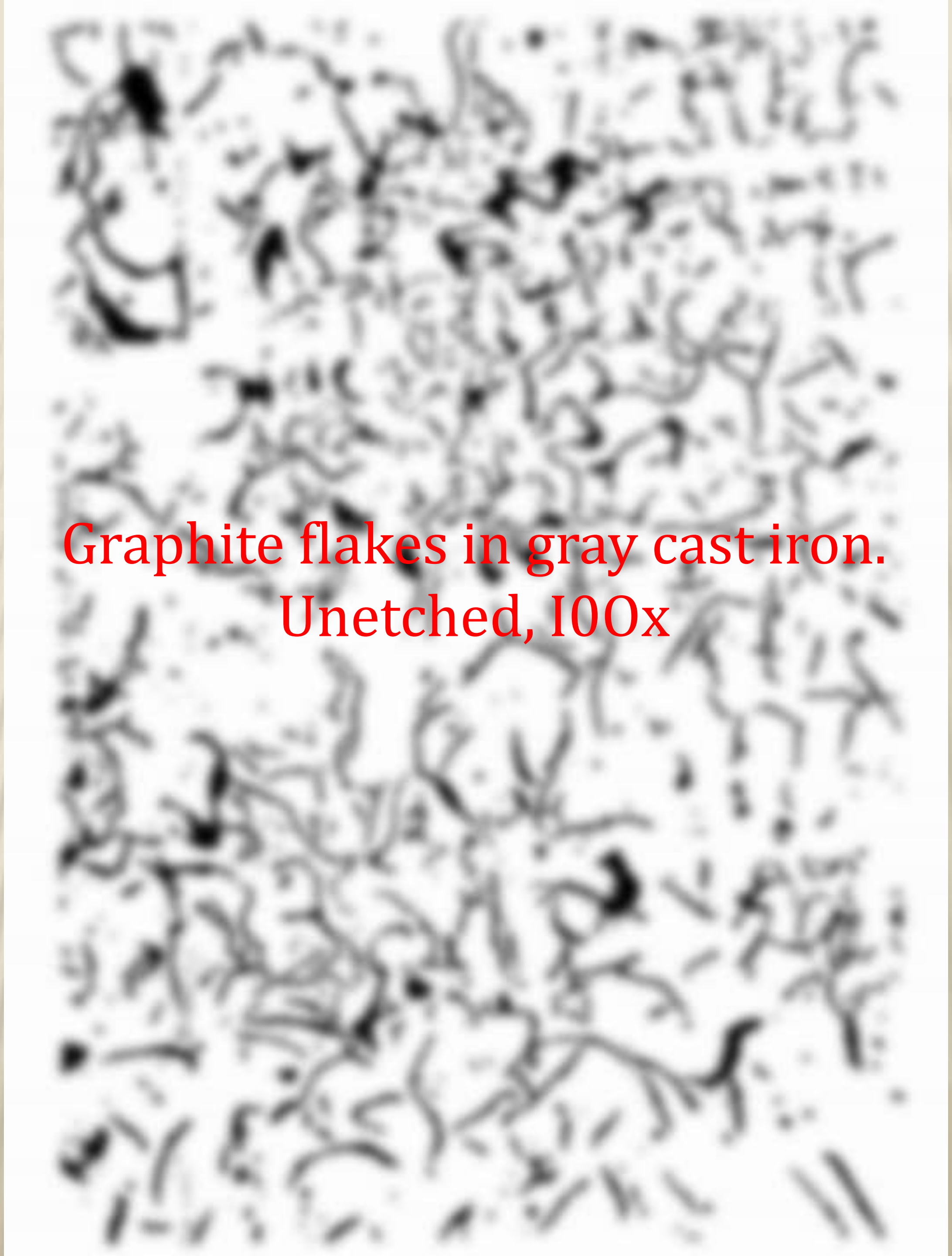


2800
Liquid
Liquid
+
austenite
Liquid
+
cementite
1.98
Iron-graphite (2075°)
Austenite
2.0
Iron-cementite (2065°)
4.3
Iron-graphite
Iron-cementite
1666
Austenite + cementite
0.69
Iron-graphite (1360°)
Iron-cementite (1333°)
0.80
Ferrite
Ferrite + cementite
Temperature, °F
0
1
2
3
4
5
6
6.67

4. GRAY CAST IRON

- At any rate, any cementite which is formed will graphitize rapidly. The graphite appears as many irregular, generally elongated and curved plates which give gray cast iron its characteristic grayish or blackish fracture.

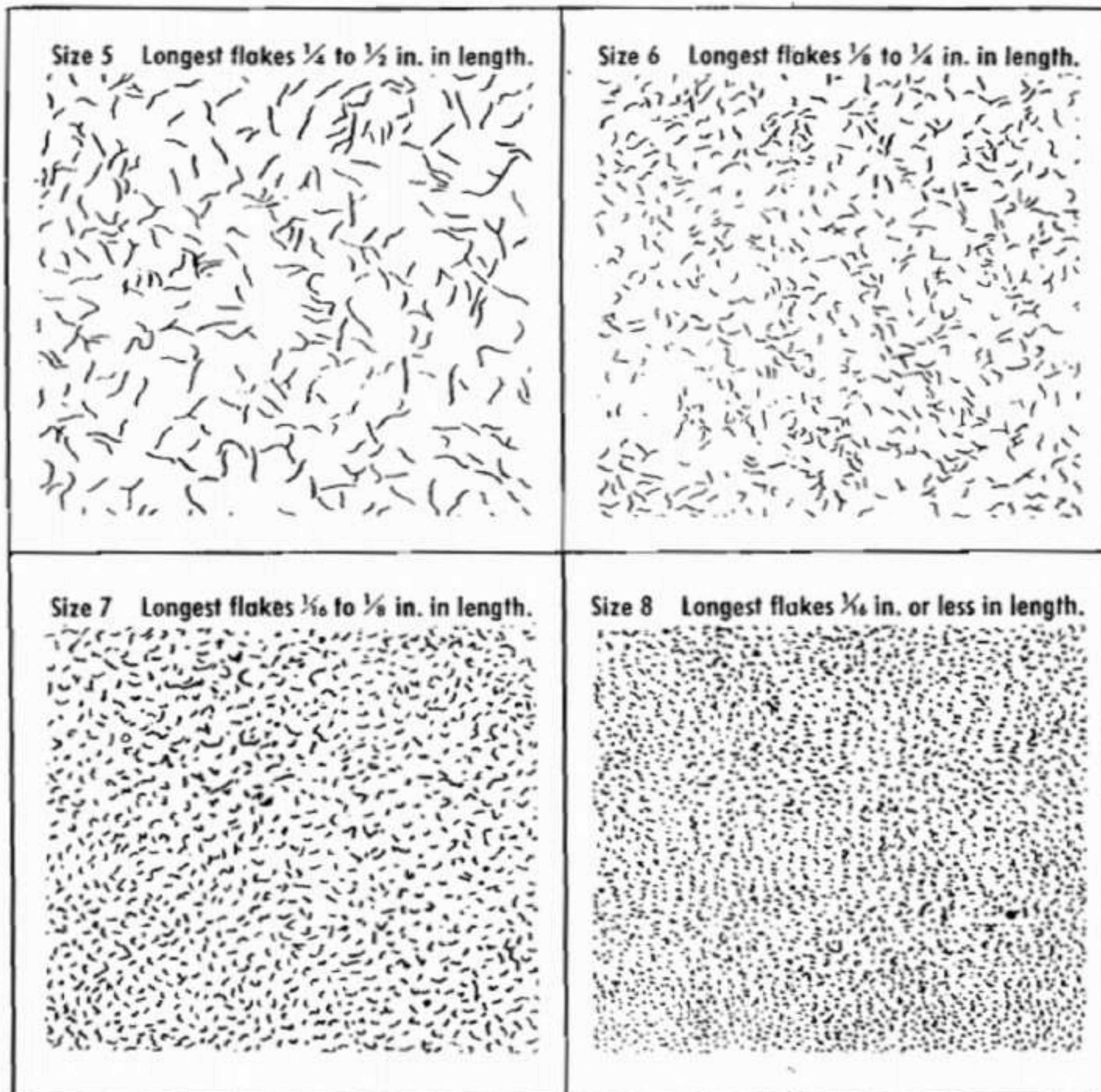
As shown in figure.



Graphite flakes in gray cast iron.
Unetched, I0Ox

4. GRAY CAST IRON

Gray iron have a different size of flakes.


Size 5 Longest flakes 1/4 to 1/2 in. in length.
Size 6 Longest flakes 1/8 to 1/4 in. in length.
Size 7 Longest flakes 1/16 to 1/8 in. in length.
Size 8 Longest flakes 1/16 in. or less in length.

4. GRAY CAST IRON

REDUCING FALKE SIZE:

The best method of reducing the size and improving the distribution of the graphite flakes seems to be by the addition of a small amount of material known as an inoculant. Inoculating agents that have been used successfully are metallic calcium, aluminum, titanium, zirconium, silicon carbide, calcium silicide , or combinations of these. They probably promote the nucleation of primary austenite, resulting in small grains, which reduces the size and improves the distribution of the graphite flakes.

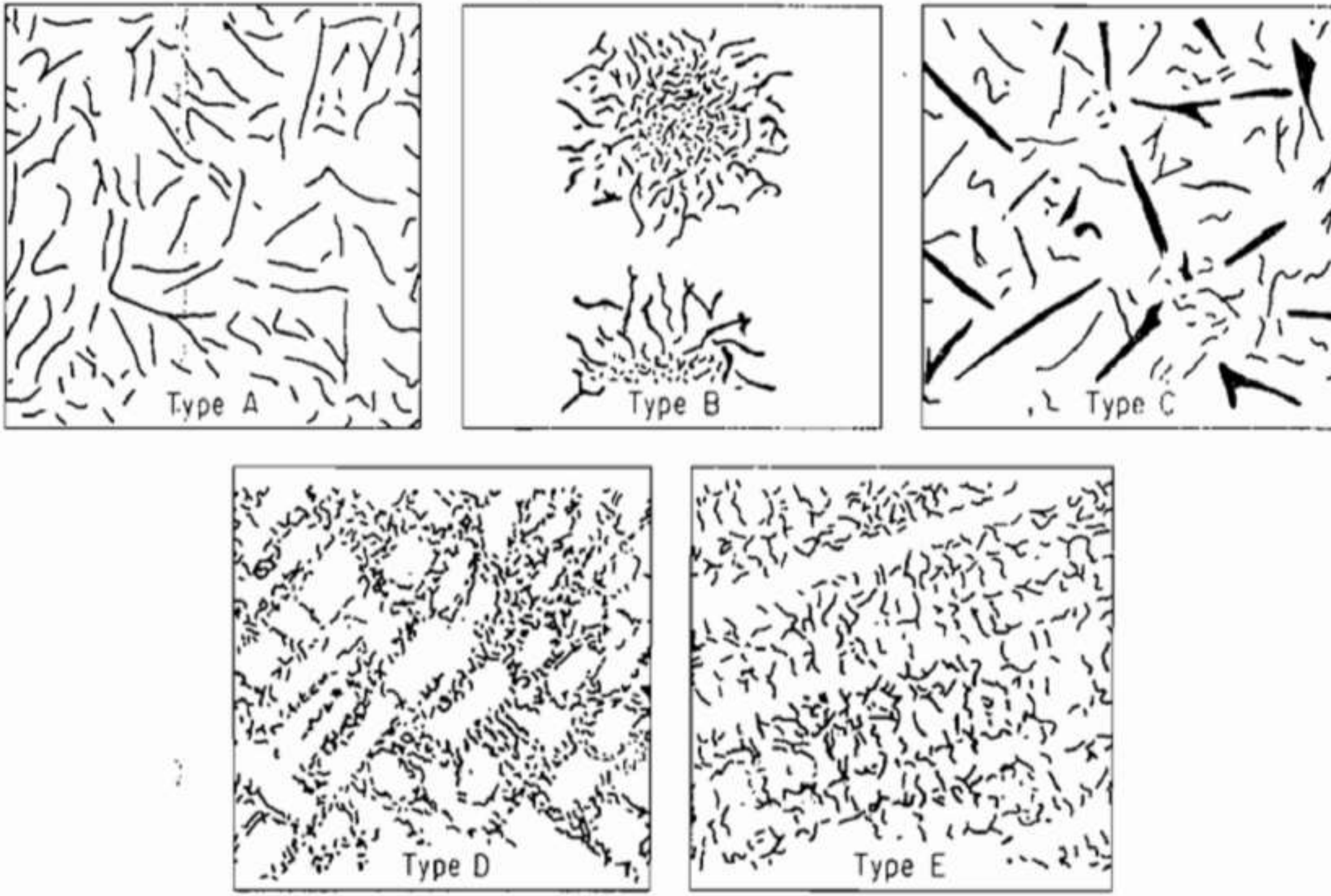


Fig. 11·18 Graphite-flake types. Type A—uniform distribution, random orientation; type B—rosette groupings, random orientation; type C—superimposed flake sizes, random orientation; type D—interdendritic segregation, random orientation; type E—interdendritic segregation, preferred orientation. (Prepared jointly by ASTM and AFS.)

4. GRAY CAST IRON

MECHAINICAL PROPERTIES:

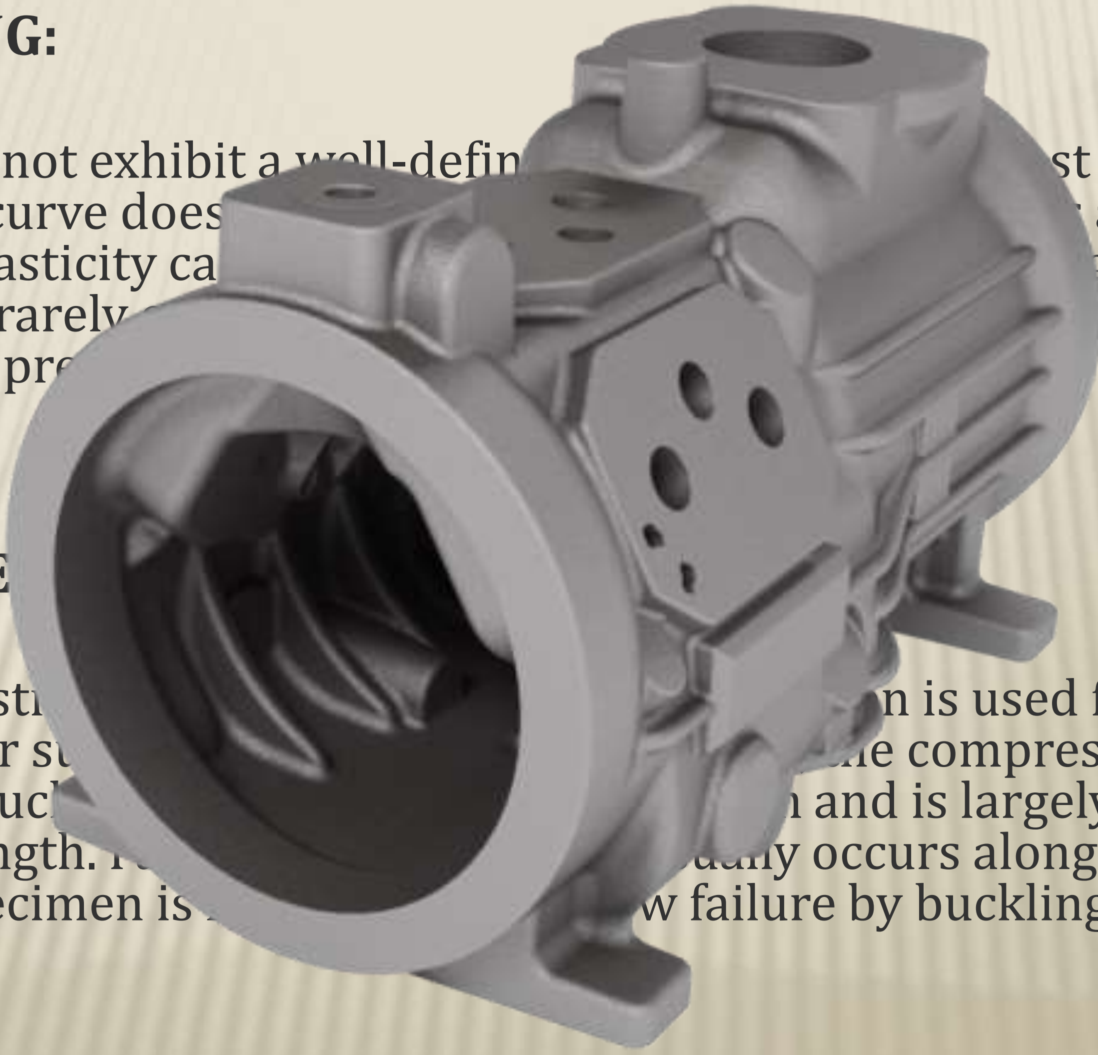
(1) TENSILE STRENGTH:

Tensile strength is important in selecting a gray iron for parts that are subjected to static loads in indirect tension or bending. Such parts include pressure vessels, housings, valves, fittings, and levers, irons above 40,000 psi in tensile strength are usually considered high-strength irons and are somewhat more expensive to produce and more difficult to machine.

4. GRAY CAST IRON

(2) YIELDING:

Gray irons do not exhibit a well-defin st mild steels. The stress-strain curve does a definite modulus of elasticity ca gation is small for all cast irons, rarely n of area is too slight to be appre



(3) COMPRE

Compressive st n is used for Machinery foundations or s e compressive strength of gray iron is muc n and is largely a function of the shearing strength. ually occurs along an oblique plane unless the specimen is w failure by buckling

TABLE The Brinell Hardness of Iron Castings Classed by General Microstructure

TYPE	BHN
Ferritic (annealed) gray iron	110–140
Austenitic irons	140–160
Soft gray iron	140–180
Pearlitic irons	160–220
Pearlitic alloy iron of low alloy content	200–250
Tempered martensitic irons	260–350
Martensitic irons	350–450
White iron, unalloyed (according to carbon content)	280–500
Alloy white iron	450–550
Martensitic white iron	550–700
Nitrided iron (surface only)	900–1,000

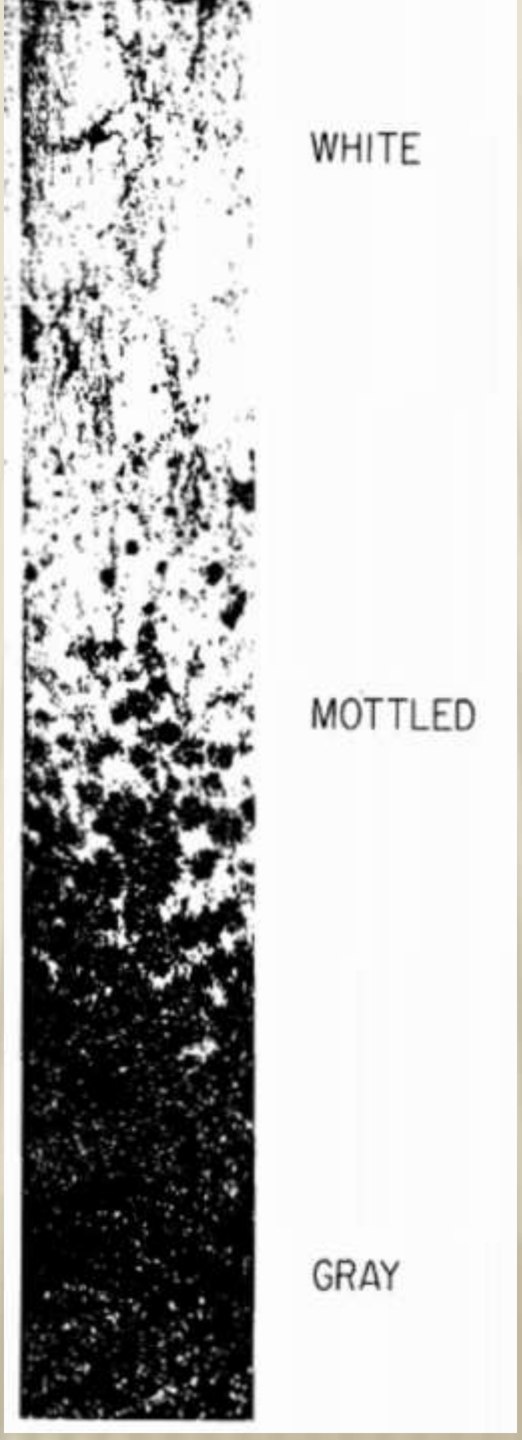

ELEVATORS DOORS


INCINERATOR
PRODUCTS
FURNACE DOOR

5. CHILLED CAST IRON

- Chilled-Iron castings are made by casting the molten metal against a metal chiller, resulting in a surface of white cast iron.
- This hard, abrasion-resistant white-iron surface or case is backed up by a softer gray-iron core.
- This case-core structure is obtained by careful control of the overall alloy composition and adjustment of the cooling rate.
- A chilled-iron casting may be produced by adjusting the composition of the iron so that the normal cooling rate at the surface is just fast enough to produce white iron while the slower cooling rate below the surface will produce mottled or gray iron. As shown in figure.

Fracture of chilled iron casting showing the white, mottled & gray portion.



5. CHILLED CAST IRON

INFLUENCE OF SOME ALLOY CONTENT:

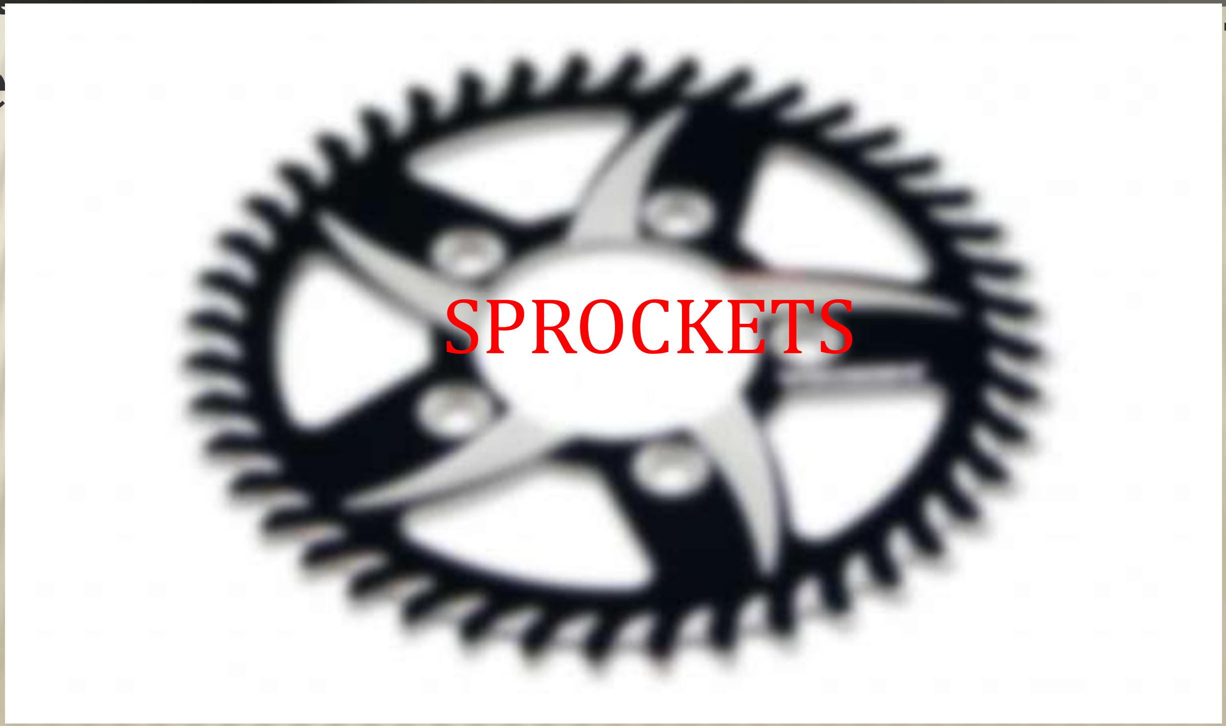
The depth of the chilled zone decrease and hardness of the chilled zone increases by:

- Carbon, silicon & manganese content.
- Phosphorus which can decreases the depth of chill. With carbon and silicon constant, an increase of 0.1 percent phosphorus will decrease the depth of chill about 0.1 in.
- Nickel which can reduces the chill depth, and its influence is about one-fourth that of silicon.
- Copper, in additions of less than 4 percent, decreases the depth of chill, but in excess of this amount the chill depth and hardness increase.

5. CHILLED CAST IRON

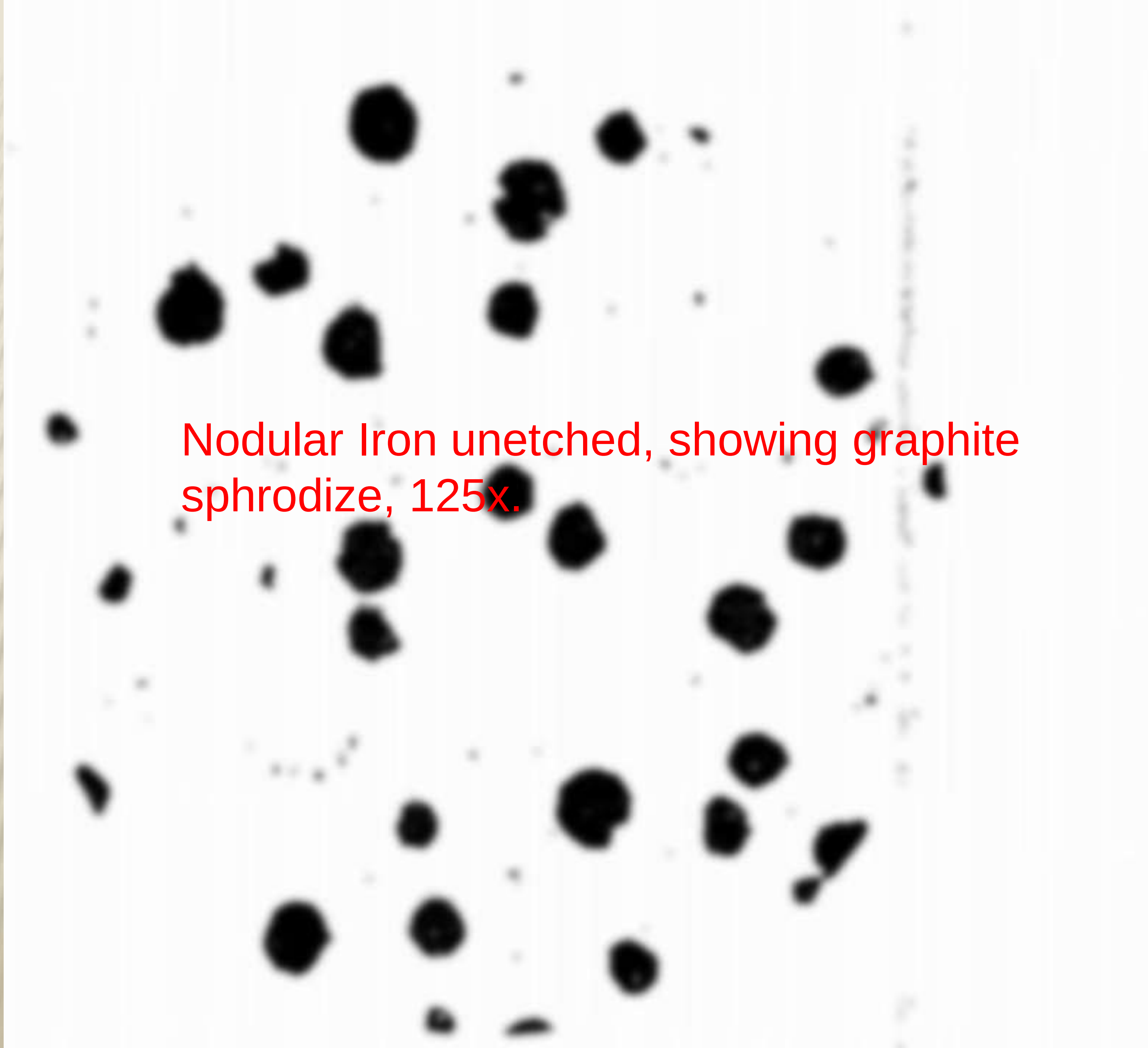
- A constant chill depth may be obtained by using a combination of alloying elements that have opposite effects. Since nickel reduces chill depth, it is common practice to add chromium produce the opposite effect. The normal ratio employed in this purpose is 3 parts of nickel to 1 of chromium.

machine



6. NODULAR CAST IRON

- Nodular cast iron, also known as ductile iron, spheroidal, graphite iron, and spherulitic iron, is cast iron in which the graphite is present as tiny balls or spheroids.
- Nodular cast iron differs from malleable iron in that it is usually obtained as a result of solidification and does not require heat treatment.
- The spheroids are more rounded than the irregular aggregates of temper carbon found in malleable iron. As shown in figure.



Nodular Iron unetched, showing graphite sphrodize, 125x.

6. NODULAR CAST IRON

PROPERTIES:

The structure of nodular cast iron have toughness, maximum ductility & machinability which can widely used in some applications.

APPLICA

- Some t ... on are in the f
  - Agric
  - Auto

7. ALLOY CAST IRON:

- An alloy cast iron is one which contains a specially added element or elements in sufficient amount to produce a measurable modification in the physical or mechanical properties.

properties such as resistance to corrosion, heat, or wear, and to improve mechanical properties and also for accelerate or graphitization.

- The most common alloying elements are chromium, copper, molybdenum, nickel and vanadium.

7. ALLOY CAST IRON:

MOLYBDE

Molybdenum s and Is a mild stabilizer of n quantities from 0.25 to ilar to that in steel. Fatigue verse strength, heal resistan are all improved.

VANADIU

Vanadium is tabilizes cementlte, and reduces graphitization. Vanadium additions between 0.10 and 0.25percent, increase tensile strength, transverse strength and hardness.

7. ALL

NICKEL:

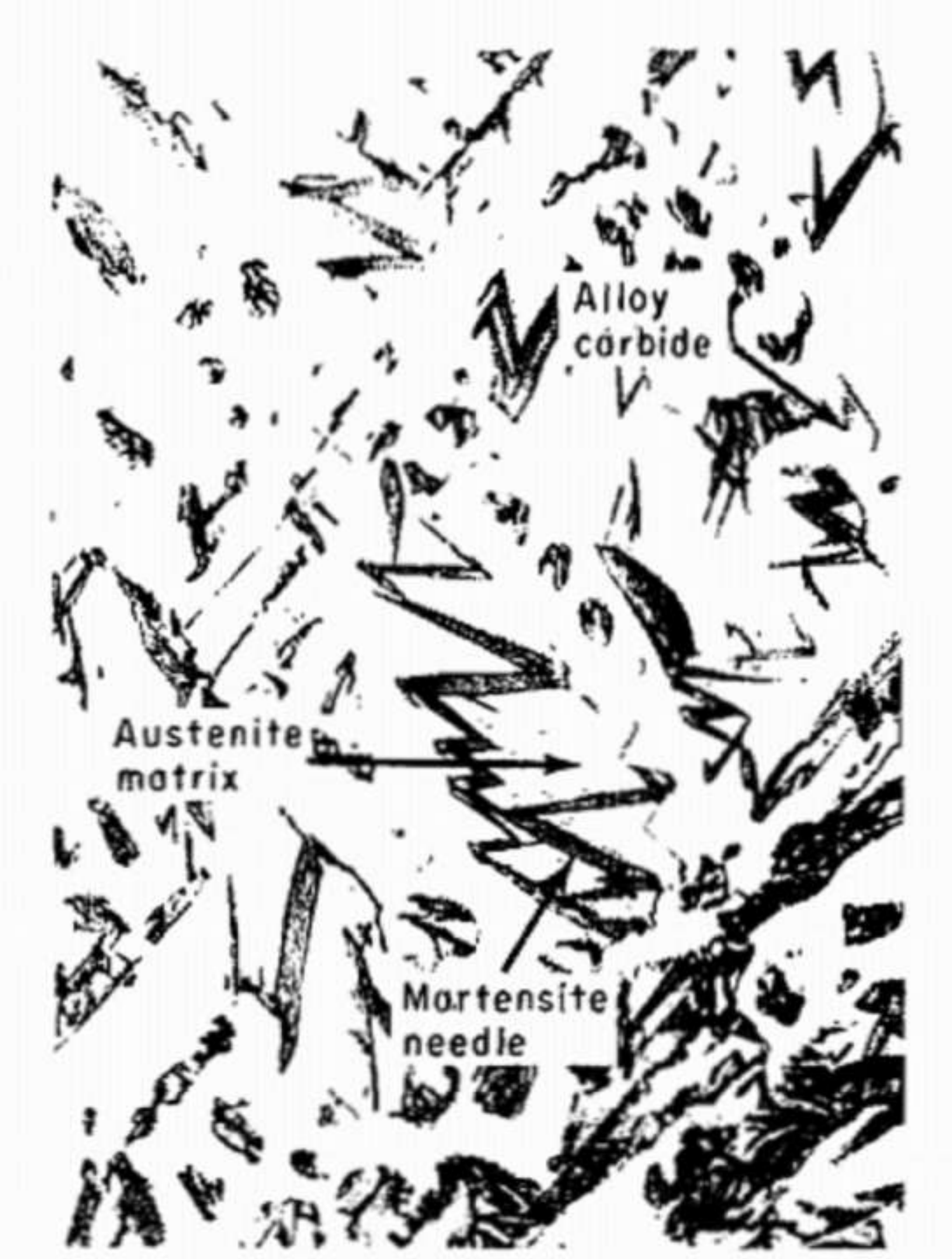
Nickel is a g 6.0
percent) in the
structure b abilizing
pearlite, an utectoid
quantity. Th ast iron
shows grap n figure.

7. ALLO

NICKEL:

Nickel is a gra 6.0
percent) in th the
structure by r tabilizing
pearlite, and r eutectoid
quantity. Thu cast iron
shows graphi n figure.

For excellent nickel in
combination added to
white cast iro



1. SUB-CRITI

The sub-critical ... re where
existing pearlite ... ess and
strength while i...

2. FULL ANNE

The full anneali ... above the
critical eutectoi ... of time
commiserate wi ... note a
ferritic microstr...

3. S

Solu
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Mar
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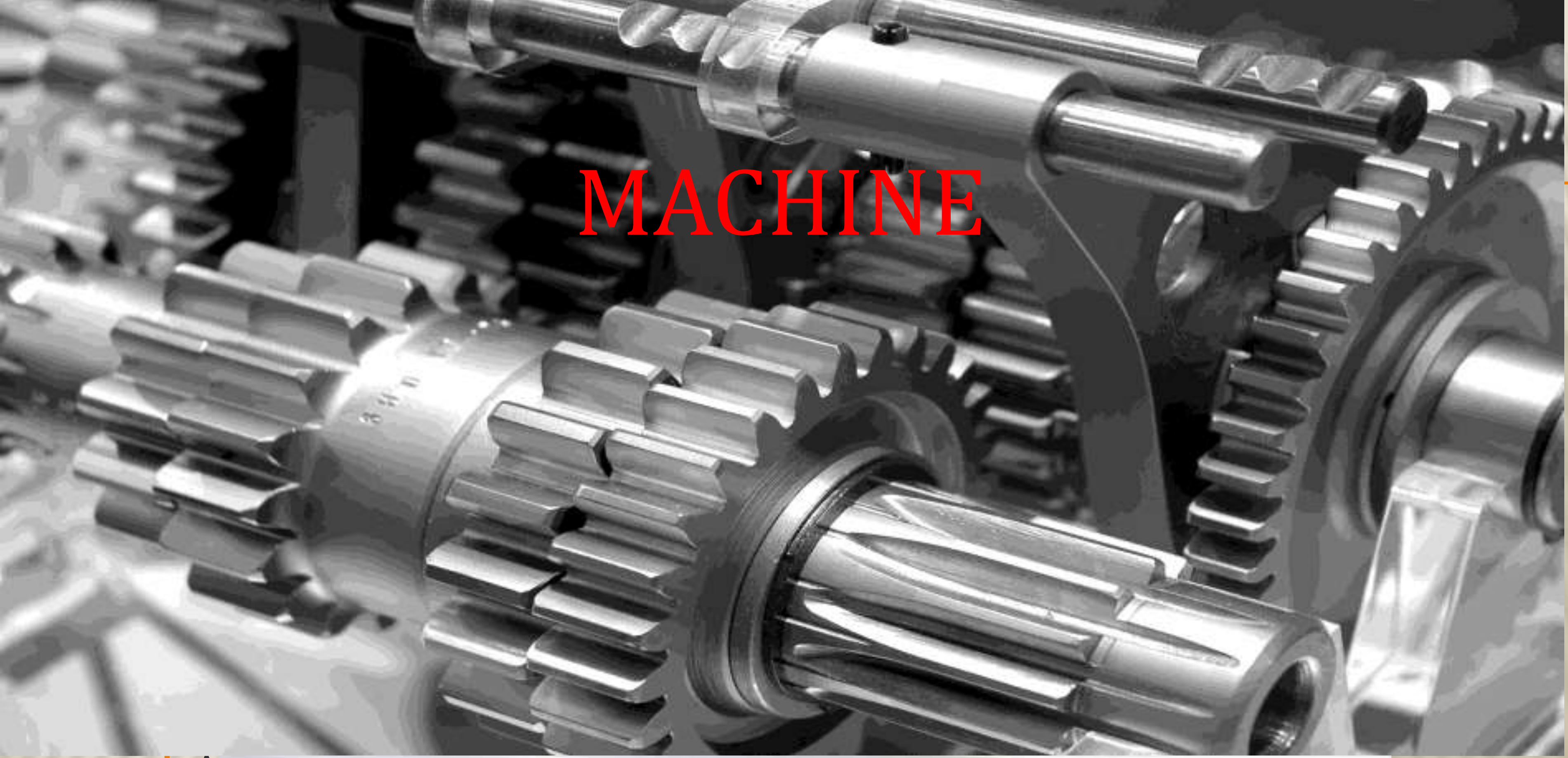

- A nder b


ANY
QUESTIONS
?


THANK
YOU