Heat Treatment

Hardening:

The basic purpose of hardening is to produce a fully Martensite structure.

We have known previously that (γ) (f.c.c) will become (α) (b.c.c) …….

by → *Cooling (slow or moderate)*

Nucleation.

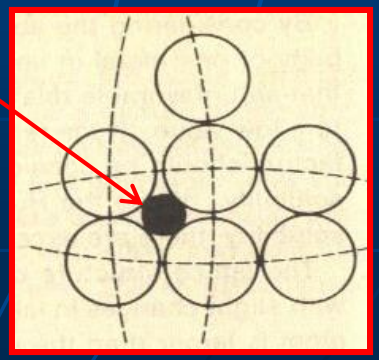
Growth of nucleus.

γ → *M (Martensite) by* → *rapid cooling.*

M - Supersaturated Solid Solution of (C) trapped in body – centered Tetragonal structure (b – c. t), the highly distorted lattice structure →

high hardness Martensite M – appear microscopically as white needlelike or a circular structure.

Carbon (Solute) in Iron (Solvent) forms the basis for hardening steel.



***Distorted lattice structure*: will exist in the region of the solute atom. This is the primary basis for the strengthening of a metal by alloying.**

The Transformation is:

- Diffusionless (no change in chemical composition).
- Proceed only during cooling and ceased if cooling is interrupted.
- Depend on Temp. decrease and is independed on time.
- Thermal is opposite of Isothermal (transformation at constant Temp.
- Can't be suppressed.
- Is never completed and small amount of retained γ will remind even at low Temp.

M_s :- The temp. of the start of (M) formation can be changed by cooling rate and it is a function of chemical composition only.

M_s formula:-

$$M_s = 1000\,(^{o}f) - (650 \times \%C) - (70 \times \%Mn) - (35 \times \%Ni) - (70 \times \%Cr) - (50 \times \%Mo)$$

M_f :- (The Temp. of the end of (M) formation (see fig. 6).

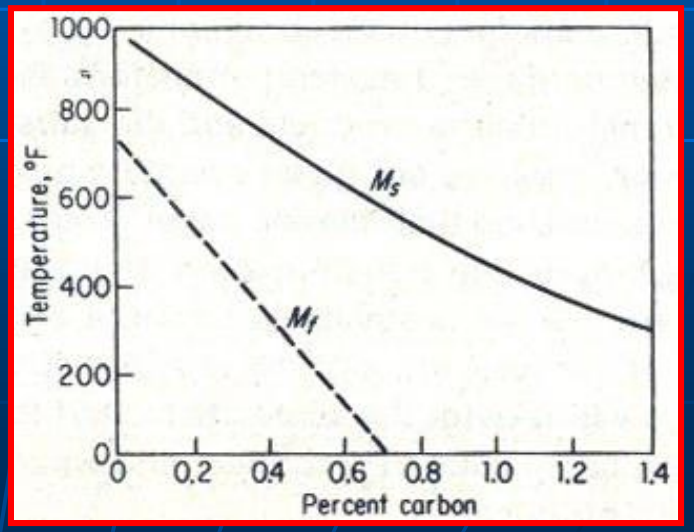


Fig. (6): Influence of % C on (M) range.

❖ ***Critical cooling rate (C. C. R):*** **is the minimum cooling rate (^{o}f / sec) that will avoid the formation of any of softer product of transformation and it is depend on:** → ***Chemical composition.***

→ ***γ grain size.***

Isothermal – Transformation Diagram (I. T. D):

The steps that is usually followed to determine an (I. T. D) are:

1) *Prepare a large number of samples cut from the same bar (0.8%C), the samples are wire threaded through a hole.*
2) *Place the samples in a furnace at Temp. of (1425 ^{o}f) for a large enough time.*
3) *Then place the samples in a molten – salt bath which is hold at a constant subcritical Temp. (below A_1, (see fig. 1)), say 1300 ^{o}f.*
4) *Repeating step (3) for a varying time interval in the molten – salt bath, then each group of the samples is quenched in cold water (C. W.).*
5) *After cooling, each sample is checked for hardness & studied microscopically.*
6) *The above steps are repeated at different subcritical Temp. until sufficient points are determined to plot the curves of I. T. diagram.*

❖ **Steps (3, 4, 5) above are shown schematically in fig. (7) below:**

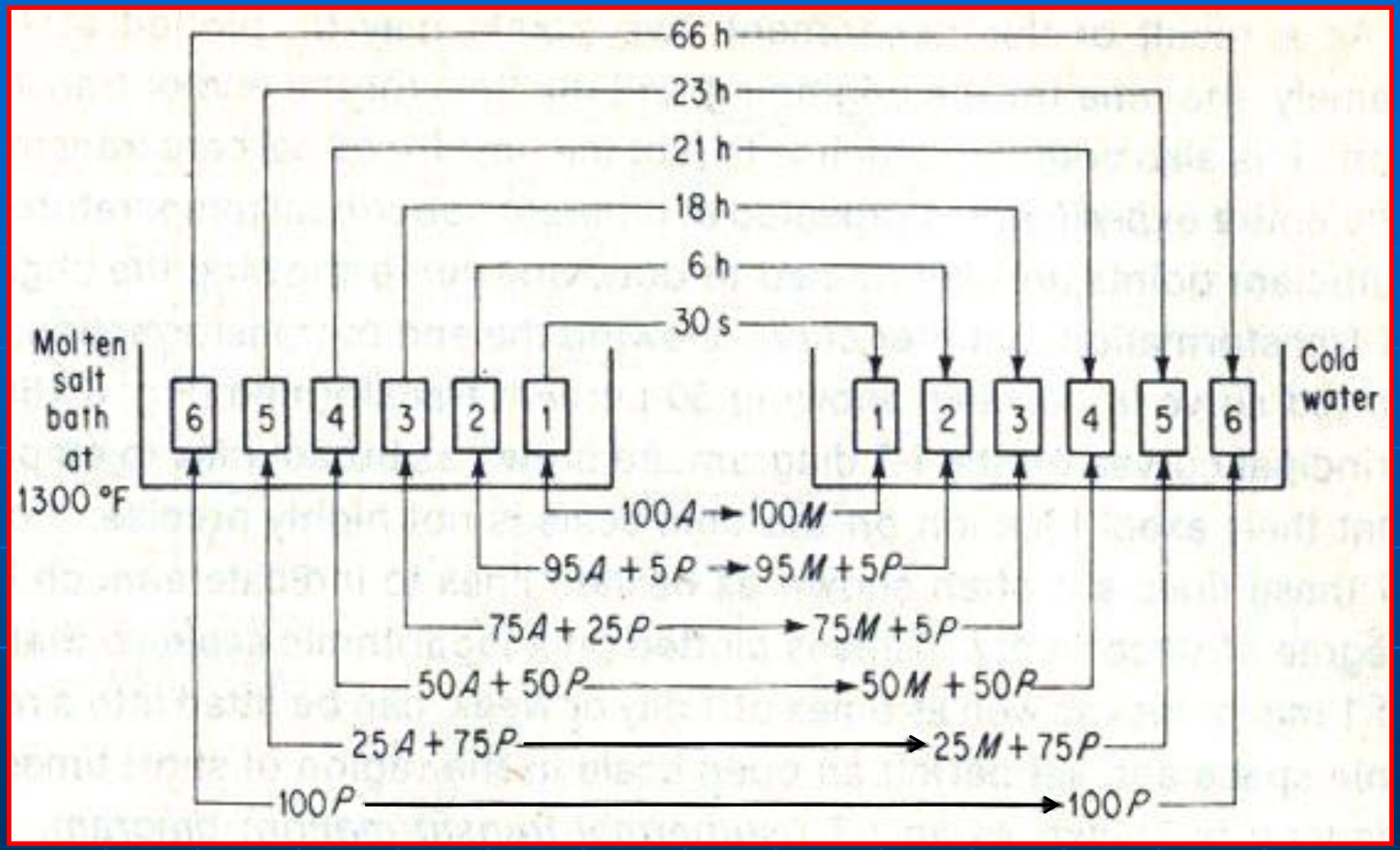


Fig. (7): The progress of (g) transformation to coarse Pearlite at 1300 ^{o}f as related to the structure at room temp. (R_T).

❖ *The typical Isothermal Transformation Curves at 1300 °f and several microstructure are shown in fig. (8) below:*

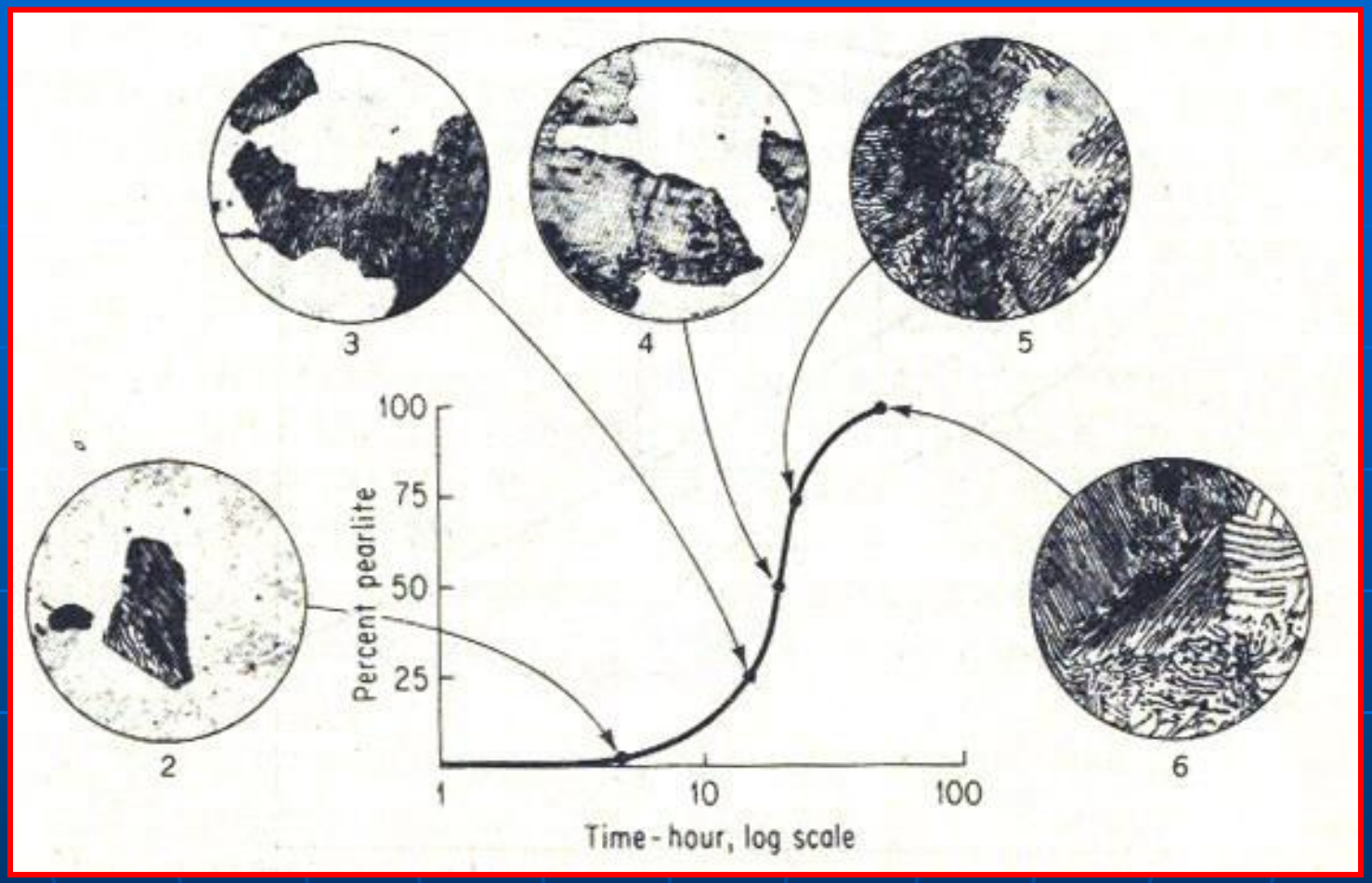


Fig. (8): The Typical Isothermal – Transformation Curve of ($\gamma \longrightarrow$ P) at 1300 °f.

❖ *Notice that the transformation from ($\gamma \longrightarrow$ P) is not linear.*

❖ **As a result of this experiment, two points may be plotted at 1300 °f namely the time of beginning & the time for the end of transformation.**

❖ *The entire experiment is repeated at different subcritical Temp. until sufficient points are determined to draw one curve showing the beginning of transformation & the other curve shows the end of transformation, the dotted curve in between showing 50% transformation, as shown in fig. (9):*

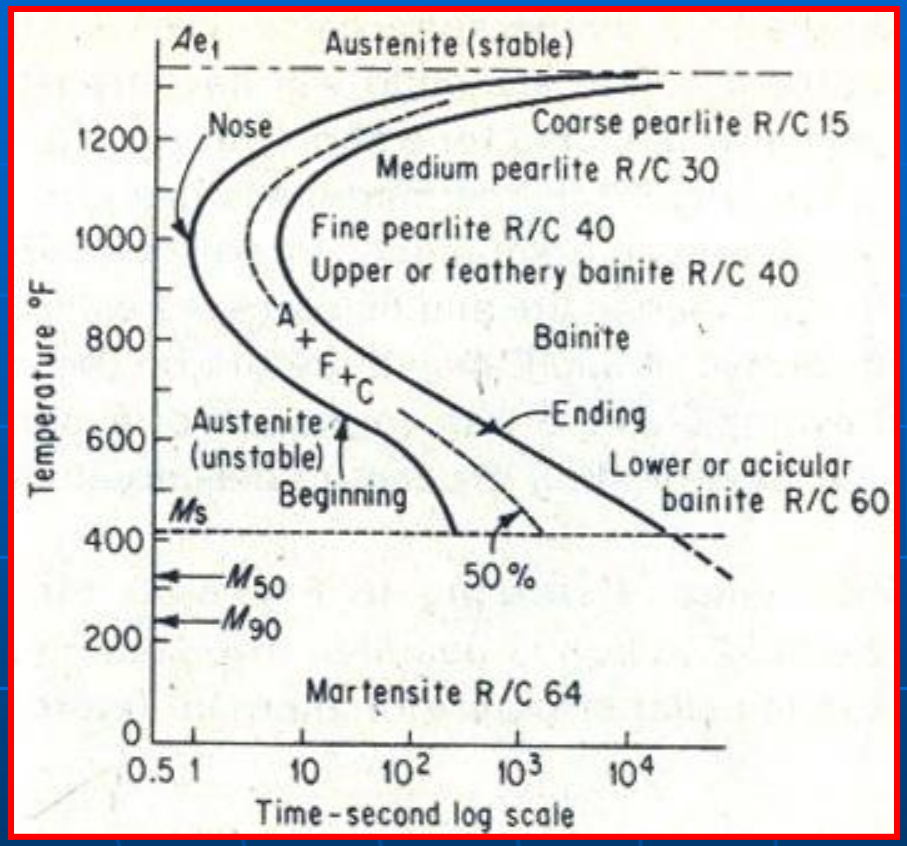


Fig. (10): I. T. Diagram of (0.8% C) Steel.

❖ *The I. T. diagram for (0.8% C) is shown in fig. (10) above.*

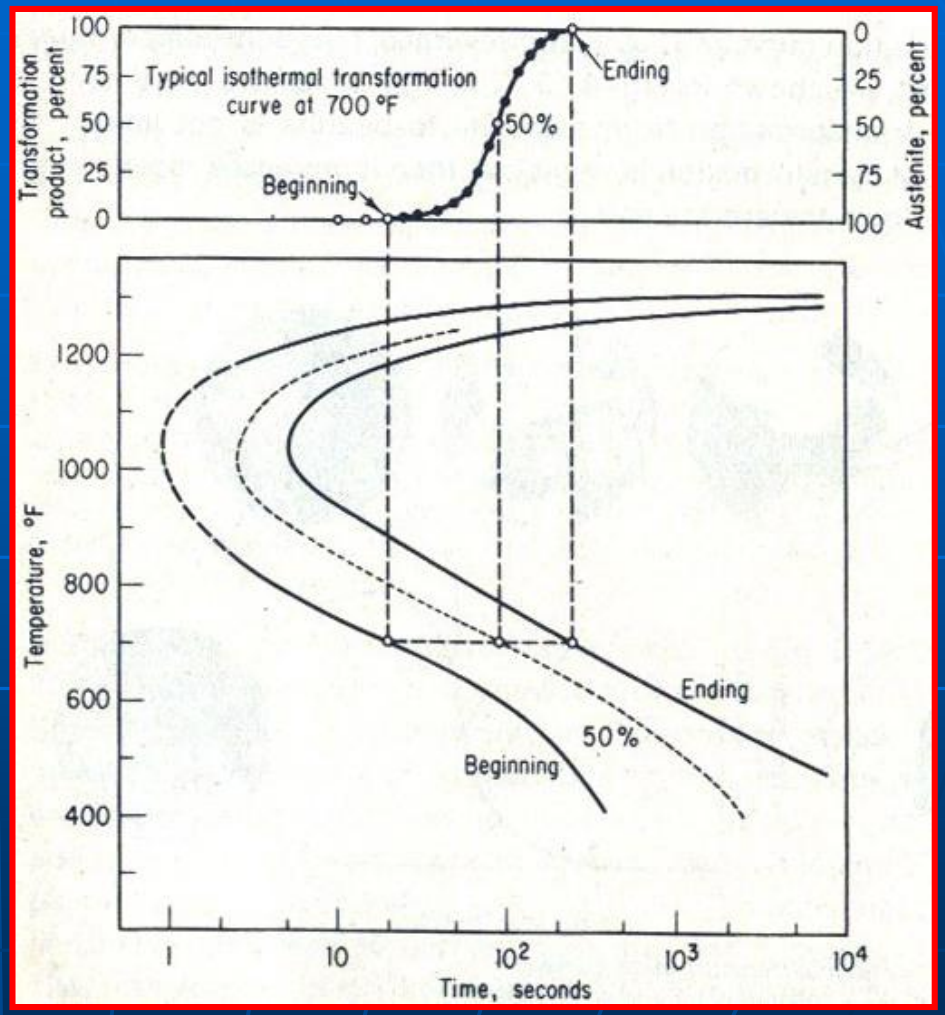


Fig. (9): Diagram showing how measurements of Isothermal – Transformation are summarized by the I. T. diagram.