TYPE METAL FOR PRINTING

An alloy of Lead, Antimony and Tin

ENGINEERING MATERIALS TERM PAPER

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TYPE METAL FOR PRINTING

INTRODUCTION

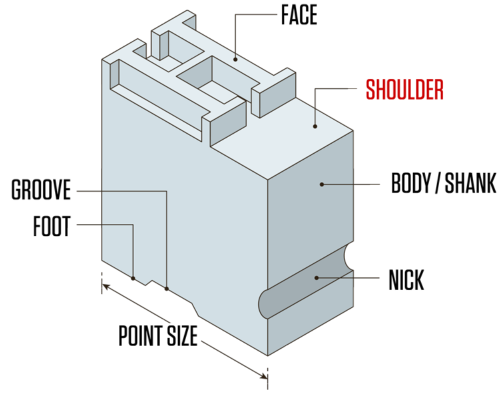
‘Type Metal’ is mainly a Printing term. It refers to a series of Alloys, which consists mainly of lead, tin, and antimony in different proportions, which are used for making type characters for printing.

The proportions of these constituent metals may vary in the range: lead 50–86%, antimony 11–30%, and tin 3–20%. Antimony is added to lead for durability. Tin helps in reducing the gap between the coefficients of expansions of the matrix and the alloy and in reducing the Melting point of the alloy. The conditions required for the Type metal is that it should be durable, produce a true and sharp cast, and retain correct dimensions and form after cooling down. It should also be easy to cast, at a reasonably low melting temperature, iron should not dissolve in the molten metal, and mold and nozzles should stay clean and easy to maintain.

MOVABLE TYPES

Printing is a process, which is used for mass reproduction of text and images using a master form or template. The process of printing has evolved over time.

Movable type is the system and technology of printing and typography that uses movable components to reproduce the elements of a document (usually individual alphanumeric characters or punctuation marks) usually on the medium of paper.



Movable metallic types **Parts of a Metallic Type**

Earlier Wooden Blocks were used for making types for printing, which is pressed over ink and printed subsequently. But as time passed, Metals and to be more specific, Alloys started taking up this job.

Johannes Gutenberg, introduced the metal movable-type printing press in Europe, along with innovations in casting the type based on a matrix and hand mold. Gutenberg was the first to create his type pieces from an alloy of lead, tin, and antimony. These Types of specific characters were used to print, which reduced a human effort by a large margin.

This group of Metals formed alloys, in which the composition of metals can be varied to make alloys of different characteristics. This group of Alloys later came to be known as Type Metal, which are used for the Printing processes.

COMPOSITION

There are Different types of Type metals, which are used for printing, which include the Linotype and Monotype alloys. Linotype alloys are used to make Types in which a whole line in a page is cast on the type. While in Types made by the Monotype alloys, each character is present on separate types and printing is done letter by letter.

These two alloys have different compositions of metals in them. We will concentrate on Monotype alloy.

Raw Type metal(Monotype alloy)

The Monotype alloy has the following metallic composition-

1. Lead(74%): Type metal is an alloy of lead. Pure lead is a relatively cheap metal, is soft thus easy to work, and it is easy to cast since it melts at 327 °C. However, it shrinks when it solidifies making letters that are not sharp enough for printing. Also Lead will easily deform while using and it is necessary to use an alloy of Lead for this purpose. Lead is exceptionally soft, malleable, and ductile but with little tensile strength.
2. Tin(10): It promotes the fluidity of the molten alloy and makes the type tough, giving the alloy resistance to wear. The alloy formed is harder, stiffer and tougher than lead and helps in reducing the Melting point of the alloy(lesser shrinkage).
3. Antimony(16): It is a metalloid element, which melts at 630 °C. Antimony has a crystalline appearance while being both brittle and fusible. When alloyed with lead to produce type metal, antimony gives it the hardness it needs to resist deformation during printing and gives it sharper castings from the mold to produce clear, easily readable printed text on the page.

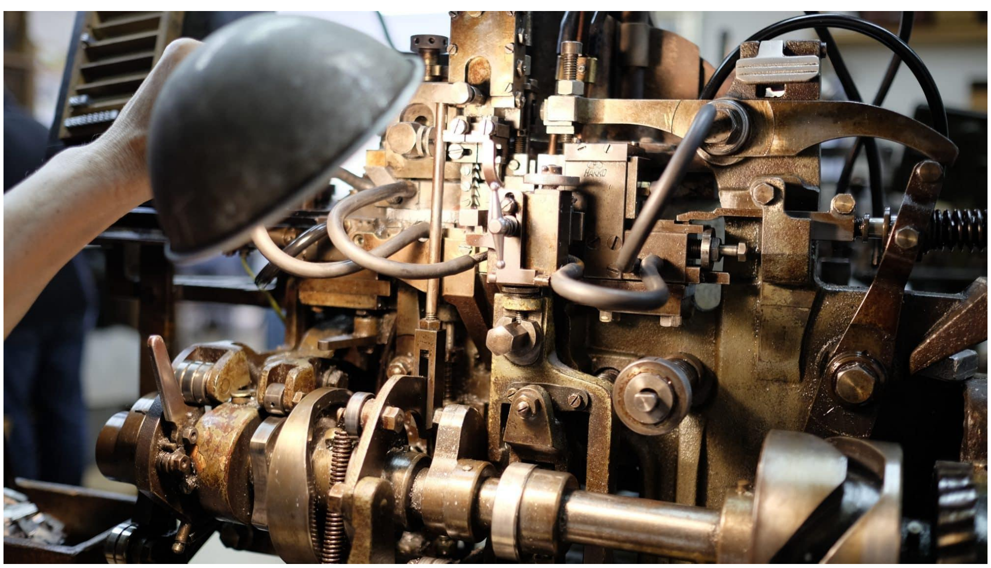
HOW TO PRODUCE TYPES

Types are produced mainly by the Casting process.

The Type metal alloy is made and is supplied for casting.

The Traditional Type Casting process is a technique used for casting the individual letters for printing, by pouring molten metal into brass molds called matrices. The individual letter types produced after casting are referred to as Sorts. The produced sorts are reused for printing and the molds need to be made again. The reusing of types results in less sharp printing and hence poor quality text.

Hot metal typesetting is a technology that is widely used now, which involves casting and arrangement of types and making it ready for printing. This method injects molten type metal into a mold that has the shape of a character. The individual sorts are arranged in a meaningful manner(in words, etc) and hence completing the typesetting process. The resulting sorts are later used to press ink onto paper. The types produced here are melted and cast once again, so as to produce sharp text with clarity. The molds are reused.



Hot metal Type Setter

Hot metal typesetting was developed in the late nineteenth century as a development of conventional cast metal type. Nowadays, specialized machines called the Hot metal Typesetter are used for this process.

WHY IS TYPE METAL USED IN PRINTING

The main requirements for a metal or alloy to be used for typecasting are-

- It should be cheap. A large number of Sorts need to be made for typecasting and hence a large amount of metal is required for that. So the material used should be cheap.
- It should have hard and sharp edges. The print produced should be clear and hence the material used should not deform easily.
- It should have a considerably low melting point. This helps in reducing the production cost by saving energy and also reduces the damage to mold materials.
- Low casting shrinkage, which gives more accurate types.

Hence type metal is used for this process, which satisfies these conditions.

Lead, Antimony, and Tin, which, when alloyed, form the type metal series.

Lead is a soft, silver-grey metal with a melting point of 327^{o}C, found principally in nature as galena, a lead sulphide. It is one of the cheapest and softest metals and Lead alone is too soft to be used as a Type metal and lacks many other valuable properties needed for type metal purposes.

Antimony is a white, brittle crystalline metal, with a melting point of 630^{o}C, and is obtained from Stibnite, which is a compound of antimony and sulphur. It is used in type metals from 3% to 23% to increase hardness and fluidity.

While adding Antimony into Lead to form an alloy, it hardens the material, and makes sharp edges when in solid form, thus making the substance suitable for the printing process.

Tin is a silver-white metal melting at 232^{o}C. It occurs in nature as an oxide termed cassiterite. The addition of Tin helps in further lowering the Melting point of the Alloy.

Hence when we attain the composition (Pb:74%, Sn:10%, Sb:16%), we get the alloy suitable for the Monotype Printing. This metal has the lowest melting point of all type metal alloys, runs freely when melted, and hardens abruptly on cooling to produce a dense faced casting. The formed alloy is a solid solution in which Lead is the solvent and Antimony and Tin are solutes.

By varying the composition to include increasing amounts of tin and antimony, a useful hardness increase can be obtained to meet applications requiring heavy pressure, and to provide superior resistance to severe wear arising from various paper finishes.

MECHANICAL PROPERTIES

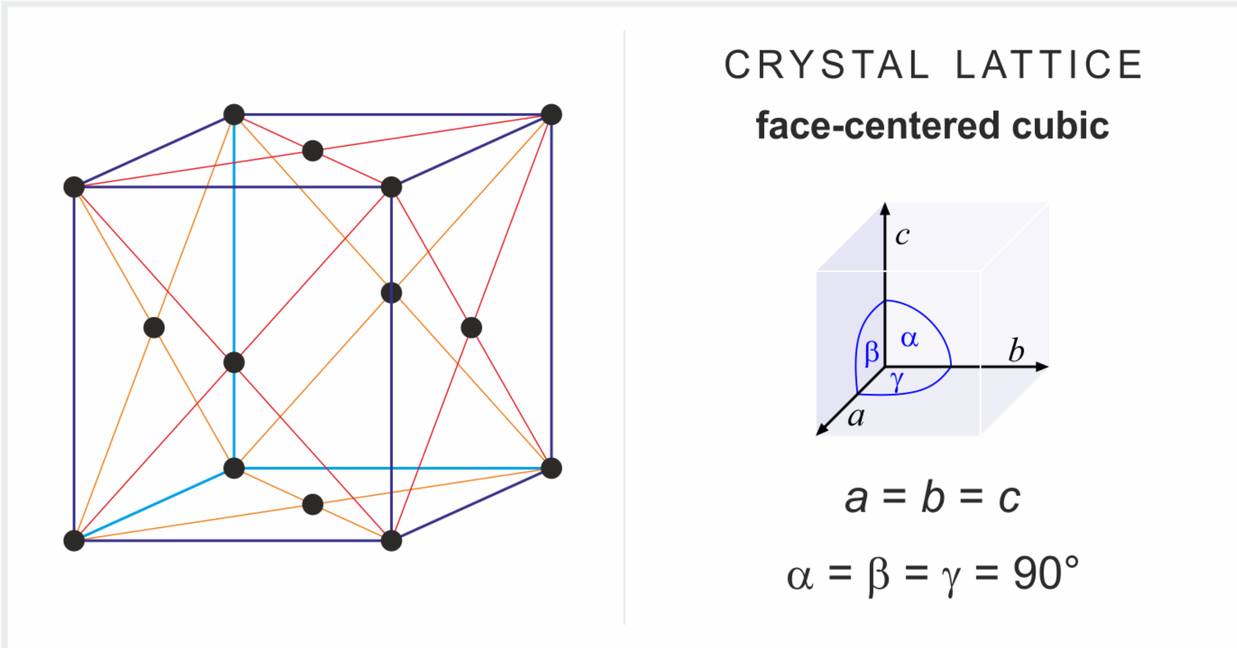
Monotype alloy used for printing has the following properties-

- Appearance: Metallic Solid
- Melting Point: 185-250 °C
- Density: 9.63 g/cm^3
- Solubility in H2O: Approx. 50%
- Coefficient of thermal expansion @15-110C ($x10^{-6}$ K^{-1}): 24.0
- Thermal conductivity @23C (W m^{-1} K^{-1}): 50.2

CRYSTAL STRUCTURE

In the solid solution of the Type metal alloy, Lead is the major metal with 74% of the total, followed by Antimony with 16%, and Tin with 10%. So Lead is the solvent metal in this alloy. Antimony and Tin, together form the solute metals.

Lead has a Cubic crystal structure(a=b=c; alpha=beta=gamma=90 degrees), with Face Centered Cube(FCC) Bravais Lattice. So the Type metal alloy has FCC crystal structure(In FCC, the atoms are present at the corners and also at the face centers of each unit cell).



Here Type metal is a Solid solution of Lead, Antimony, and Tin, with the crystal structure being of one of the elements, that is Lead(FCC). Here Lead is the Solvent metal and Antimony and Tin are the solute metals.

The atomic radii(R) of the elements are as follows-

Lead	154pm
Antimony	133pm
Tin	145pm

From this, it is seen that the radius of the solute atom is close to the solvent atom. Hence Type metal forms a Substitutional solid solution, i.e. some of the lead atoms are replaced by Tin and Antimony atoms.

The solute atoms are not that small so that they can sit in the octahedral voids formed between the lead atoms to form interstitial solid solutions.

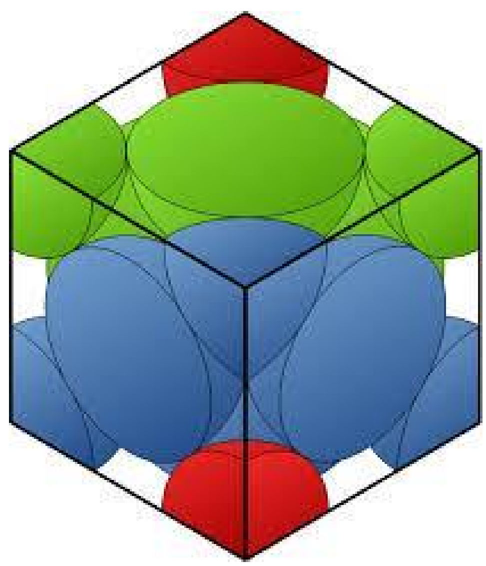
Talking about the solubility of the solid solution of Type metal according to the Hume Rothery Rules, the solute atoms can attain infinite solubility inside the solvent.

1. The final crystal structure of the Type metal is the same as lead's crystal structure, ie FCC.
2. $((R_{solvent} - R_{solute})/R_{solvent})*100 < 15$
3. Electronegativity of Lead. Antimony and Tin are close enough.

These 3 conditions are satisfied and hence Antimony and Tin can attain infinite solubility in Lead.

PACKING FRACTION

Type metal has FCC crystal structure, with Tin and Antimony atoms occupying some of the Lattice points of the Lead atoms(all these atoms have approximately equal radii). So the packing fraction of Type metal alloy can be calculated by calculating the packing fraction of the pure lead metal which has FCC structure.



Now length of side =a

Radius of one atom=r

root(3a)=4r

From this we can calculate Packing Fraction as =

(volume occupied by atoms)/(volume of the unit cell) *100

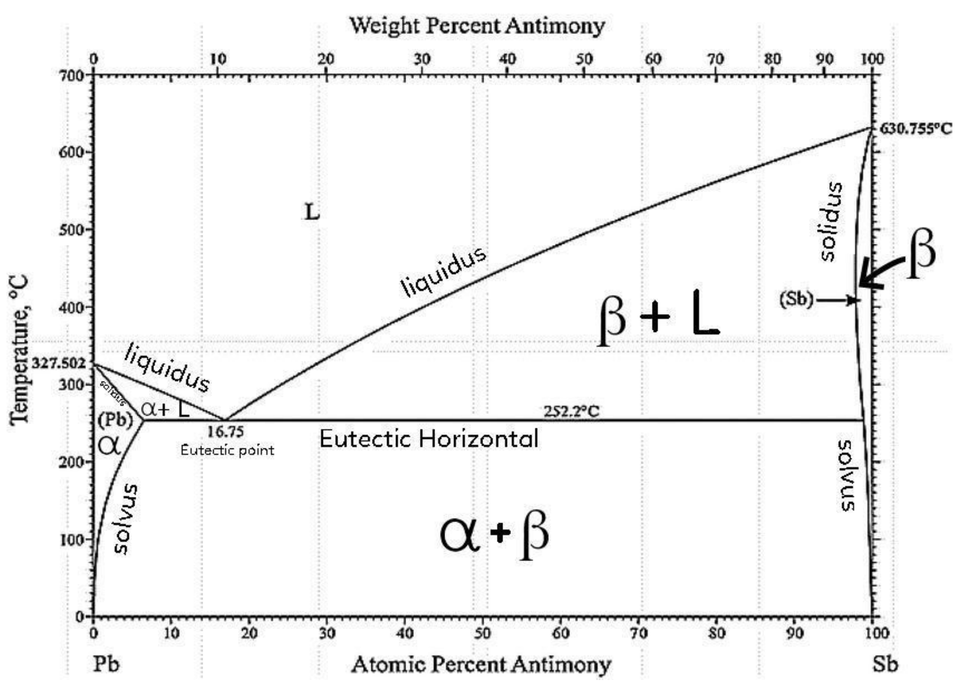
Hence for Type Metal, approximate

Packing Fraction = 74%

PHASE DIAGRAM

The Type metal has 3 constituent metals and hence it will have a Ternary Phase diagram. But as a ternary phase diagram is more complex, here we will see a binary phase diagram of Lead-Antimony alloy, as antimony is more required in the type metal alloy, than tin as it hardens the alloy.

Binary phase diagram of Type metal alloy(Lead-Antimony alloy)



Phase diagram of Pb-Sb alloy

In this phase diagram, Temperature(degree Celsius) is taken on the Y-axis, and the percentage of antimony in the alloy is taken on the X-axis.

Melting point of Lead: 327.502 degree Celsius

Melting point of Antimony: 630.755 degree Celsius

This is a Eutectic **System**.

We can find Liquidus, Solidus, Solvus lines, and a Eutectic horizontal.

The Eutectic point(where 2 liquidus meets) is at 16.75% antimony. Hence the Eutectic composition has **83.25%** Lead and **16.75%** Antimony.

The Eutectic temperature is found to be **252.2 degrees Celsius**.

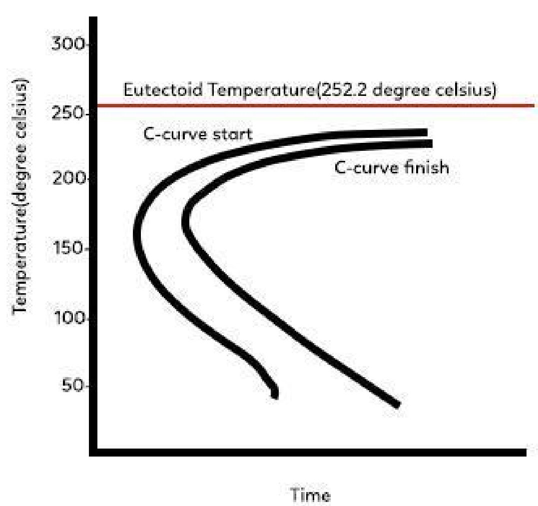
There are 6 phases, as shown in the figure.

The Eutectic reaction(Invariant reaction) taking place in this system are:

L **--->**(252.2 degree celsius, cooling) **alpha** + **beta**

TTT CURVE

While considering Lead-Antimony alloy for the Type metal, from the above Phase diagram, we can see that it is a Eutectic system. So the Time-Temperature Transformation curve for this alloy will be similar to Eutectoid steel.



TTT Diagram for Type metal

CONCLUSION

- Type metal is an alloy used for printing techniques. The alloy contains Lead, Antimony, and Tin as its constituent metals.
- Movable type is a system and technology by which printing is done by the reproduction of characters using types(objects using which the characters are reproduced). Nowadays metallic types are being used.
- Type metal has the composition(Lead 74%, Antimony 16% and Tin 10%)
- Hot metal typesetting is used to make types nowadays. It involves in pouring the molten type metal into molds, which has shapes of specific characters and then arranging them in a meaningful manner for typing. For the next typing process, the alloy is again melted and cast so as to produce sharp edges.
- Lead helps in reducing the cost, adding Antimony makes it sharper and harder, and Tin helps in reducing the Melting temperature.
- The mechanical properties of Type metal:
  Appearance: Metallic Solid, Melting Point: 185-250 °C, Density: 9.63 g/cm^3, Solubility in H2O: Approx. 50%, Coefficient of thermal expansion @15-110C ($x10^{-6}$ K^{-1}): 24.0, Thermal conductivity @23C (W m^{-1} K^{-1}): 50.2
- Type metal has an FCC crystal structure. The alloy is a Substitutional solid solution. The solute atoms can attain infinite solubility in the solvent Lead, according to Hume Rothery rules.
- Packing Fraction of Type metal = 74%.
- The Pb-Sb phase diagram is a Eutectic system with a Eutectic composition of 83.25% Lead and 16.75% Antimony, and with a Eutectic temperature of 252.2 degrees Celsius.
- The TTT curve of the Pb-Sb alloy is similar to that of Eutectoid steel, with C curves.

CITATIONS

1. MACHINE COMPOSITION *(continued)* and TYPE METAL-https://letterpressprinting.com.au/page40.htm
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