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PROCESS FOR INCREASING THE ELECTRIC CONDUCTIVITY OF TIN BRONZES

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Fig. 1.

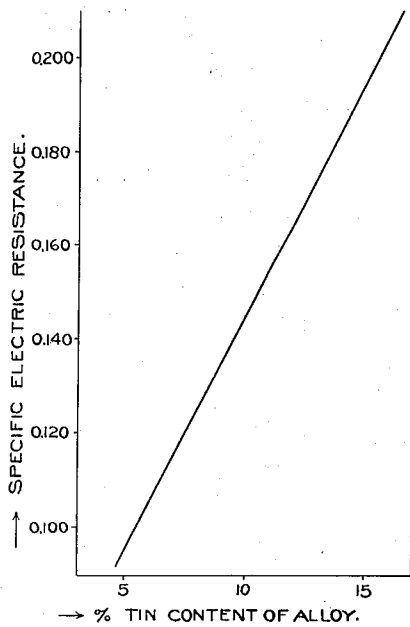


Fig. 2.

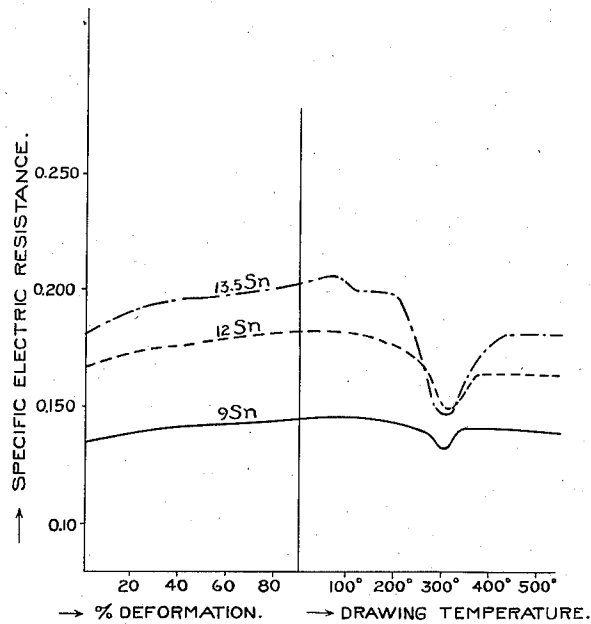


Fig. 3.

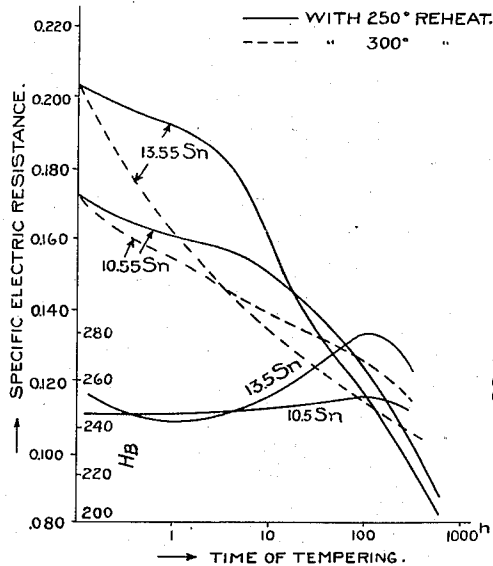
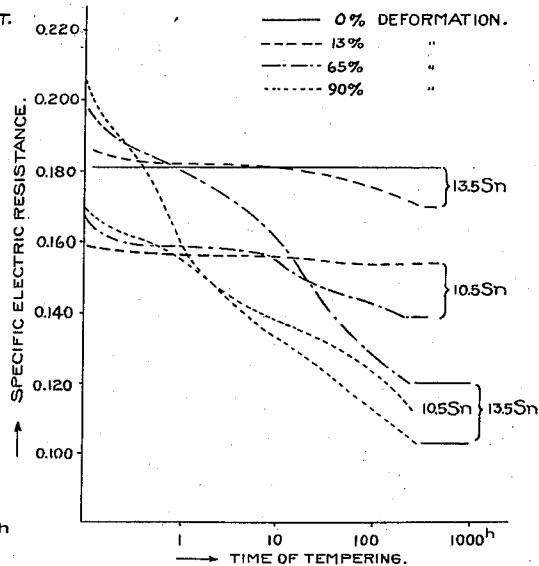


Fig. 4.



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PROCESS FOR INCREASING THE ELECTRIC
CONDUCTIVITY OF TIN BRONZES

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4 Claims. (Cl. 148—11.5)

Tin-copper alloys, with or without the addition of further constituents, are employed extensively on account of their great strength and corrosion resistance. A disadvantage of such alloys is their relatively low electrical conductivity due to the addition of tin to the copper.

Extensive investigations relating to the influence on the physical and mechanical properties of the alloy by cold deformation and the recovery of the materials from the alterations which have occurred, by subsequent tempering, have resulted in an improved process, by means of which a considerable increase of the conductivity of tin bronzes of the α mixed crystal range can be attained.

In carrying out the improved process the alloys, after any desired heat treatment, are first shaped by forging, rolling or drawing in the cold state and then tempered at temperatures between about 150° and 400° C.

The novel features which are characteristic of our invention are set forth with particularity in the appended claims. Our invention however will best be understood from reference to the following specification when considered in connection with the accompanying drawing in which Fig. 1 is a diagram illustrating the relation between the tin content and the specific resistance in

$$\frac{\Omega \text{ mm}^2}{\text{m}}$$

of the binary alloys; Fig. 2 is a diagram illustrating the relation between specific resistance percentage deformation and drawing temperature; while Figs. 3 and 4 are diagrams illustrating the relation between specific resistance and time of tempering.

The effect of our improved process is disclosed in connection with certain alloys in Figs. 2 and 3. Fig. 2 shows in the left hand portion the effect of the cold working on the electrical resistance. The right hand portion of the diagram shows the recovery of the single alloys from the resistance increase effected through subsequent tempering. As will be seen, not only is the previously effected resistance increase cancelled but the resistance drops, owing to the one hour tempering at 300–350° C., below the value of the samples not cold worked. This drop can be further increased and more particularly it can be extended to alloys of lower percentage by increasing the duration of the tempering. This will be evident from Fig. 3. In this figure, for temperatures of 250° and 300° C. the variation of the electrical resistance is

plotted for alloys containing 10.5 and 13.5% tin in dependence on the duration of the tempering period. As in Fig. 2 the alloys were shaped in a cold state before tempering to the extent of 90% reduction in the thickness. As will be seen, a very great reduction of the electric resistance occurs. This takes place at 250° without any reduction whatever of the strength as shown by the diagrams of the Brinell hardness. This condition is of particular importance because in this way high conductivity can be attained with great strength, i. e. those properties can be produced, which are required for current conducting springs or for current conducting electrodes or contacts for the electrode technique. A slight drop in the hardness occurs at 300° but here also the greatest part of the cold work hardness is maintained.

In the reversed case, Fig. 4 shows that the cold strengthened state is a requirement for this reduction of the electrical resistance. In this figure, for the alloys shown in Fig. 3, the effect of tempering at 300° C. is indicated for increasing degree of deformation. No change is effected in the period of tempering employed in connection with the non-hardened alloys. The drop becomes noticeable with a reduction in thickness of more than 10% reduction and increases continuously with the cold work hardening. A further acceleration of the drop can be attained if a repeated cold hardening is carried out immediately, i. e. after the tempering has been in progress for a certain time. This is particularly the case at tempering temperatures above about 300° C. at which a decrease in hardness already occurs owing to the tempering. Finally the reduction of the electric resistance can be still further accelerated and increased by small additions either alone or mixed of other metals or metalloids such as phosphorus, magnesium, silicon, nickel, iron, aluminum and zinc in quantities of about 0.1 to 2%. The conductivity attained is greater the higher the content of tin. For the binary bronzes containing only tin and copper the possibility of improvement extends downwardly to about 3% tin. On introducing additions, as mentioned above, this limit drops to below 1%. As far as the metallurgical basis of the process described is concerned, it is to be assumed, based on the knowledge of other systems of alloys, that it is a question of decreasing the solubility of tin in copper, i. e. of a decrease in the power of copper for dissolving tin at a low temperature. This decrease of solubility evidently cannot be brought about with the non

work-hardened alloys owing to the low temperature and the low power of diffusion consequent thereon and its effect has therefore never been observed hitherto. It is only by means of cold deformation that this phenomenon is effected within technically practicable tempering periods. As is proved by the diagrams shown in this case also the period of tempering employed to develop this result necessarily is greater than that normally required for recrystallization which takes place only at higher temperatures.

Any increase in the electrical conductivity of tin bronzes is particularly desirable since such alloys are employed in great quantities as current conducting springs. This is also the case where the bronzes serve simultaneously as constructive material and as current conducting members for instance as electrodes for welding machines, soldering irons, current collector rollers, etc. For this purpose the strengthening by tempering below the recrystallization interval, i. e. tempering without any reduction of the cold-hardening, is to be particularly recommended. Besides this, in these cases, the addition of one or several of the above-mentioned third and fourth constituent parts is also generally to be recommended, because thereby, the conductivity is still further increased, particularly in connection with the alloys having low contents of tin, down to about 1%.

What we claim as new and desire to secure by Letters Patent of the United States, is:

1. The process for increasing the electrical conductivity of tin bronzes of the α mixed crystal range having upwards of 1% tin which contain an appreciable quantity and up to 2% of material from the group silicon, aluminum, iron, phos-

phorus, nickel, zinc and magnesium, which comprises cold working said alloys to effect a reduction in thickness greater than 50% and thereafter tempering said alloys between 150° and 400° C. for a period greater than that normally required for recrystallization which takes place only at higher temperatures.

2. The process for increasing the electrical conductivity of tin bronzes of the α mixed crystal range having upwards of 3% tin which comprises cold working said alloys to effect a reduction of about 90% in thickness and thereafter tempering said alloys at a temperature in the neighborhood of 300° C. for a period greater than that normally required for recrystallization which takes place only at higher temperatures.

3. The process for increasing the electrical conductivity of tin bronzes of the α mixed crystal range having upwards of 3% tin which comprises cold working said alloys to effect a reduction in thickness greater than 50% and thereafter tempering the alloys at a temperature in the neighborhood of 300° C. for a period greater than that normally required for recrystallization which takes place only at higher temperatures.

4. The process for increasing the electrical conductivity of tin bronzes of the α mixed crystal range having upwards of 3% tin which comprises cold working said alloys to effect a reduction of about 90% in thickness and thereafter tempering said alloys at a temperature in the neighborhood of 300° C. for a period of time greater than ten hours.

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