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Copper bismuth alloys

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"Copper Bismuth Alloys."

Thesis for the Degree of Bachelor of Science

in

MINE ENGINEERING,

BY

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A large part of the time at first spent on this thesis was devoted to experimental work on an electric furnace, supplied by the Diamond Electric Company of St. Louis, Mo. This furnace was guaranteed to produce a temperature of 1649 degrees Centigrade, under 110 volts pressure.
A temperature only sufficient to melt copper, 1093 degrees Centigrade, was obtainable and on second run at this temperature, the muffle fused, either broke or short circuited the imbedded platinum wire and ruined the furnace.

I next made a furnace by taking a part of a porous cup 2 inches in diameter and 3 inches deep, cutting a spiral groove on its outer surface, winding a platinum wire 12 1/2 feet long 4/10 mm. in diameter, in the spiral groove, covering the whole with fire clay and packing with asbestos in a sheet iron clinder 3 1/2 inches in diameter, 4 1/2 inches deep. A photograph of the furnace is seen on Figure 1.

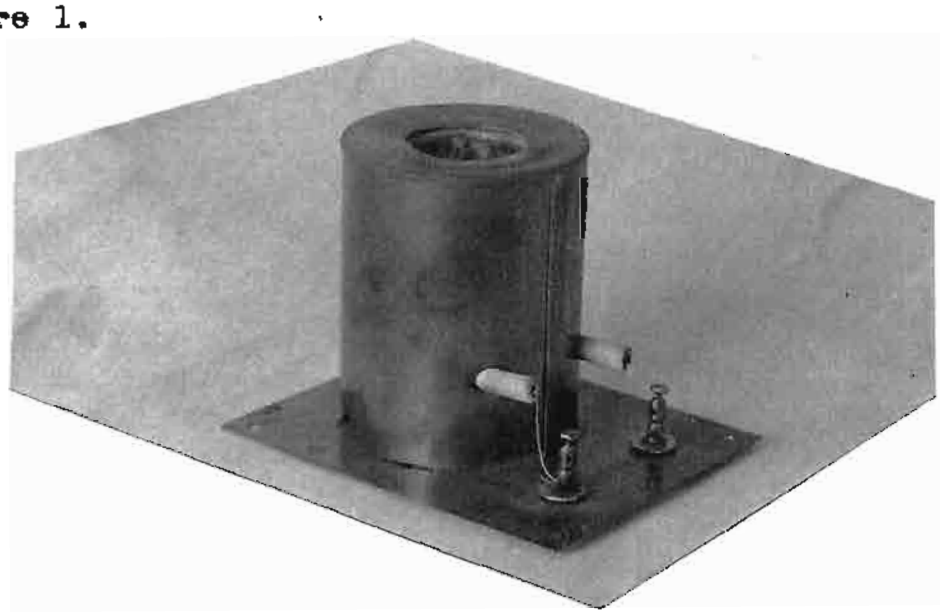


Fig. I.

A temperature of 1093 degrees Centigrade can be obtained in this furnace in 45 minutes with 110volts, this voltage being raised slowly. When the temperature of the furnace is high enough to melt copper, the terminals of the platinum wire are not red hot or tarnished. From this we may infer that a temperature closely approximating the melting point of platinum may be obtained in the muffle without running the risk of destroying the platinum by oxidation of the terminals exposed to the air.

The first object of this thesis was to determine the freezing point curve for Cu,Bi alloys. To do this it was intended to cool slowly alloys containing different known percentages of Cu and Bi. During the cooloing the alloy would be constantly stirred by a pyrometer given an eccentric motion by the apparatus illustrated on Fig.2.

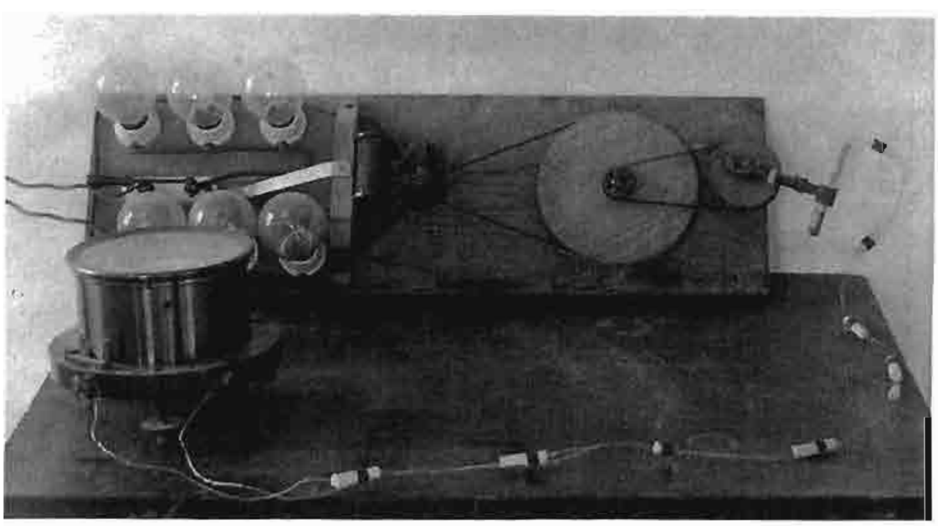


Fig. 2.

The variations in temperature being carefully noted at short intervals; the temperature at which an alloy having a true melting point separates would then be determined, and since its liquid portion would have the same composition as its solid, a sample of this liquid, analysed, would give the Cu, Bi contents of the alloy having the true melting point. The composition of this alloy and its melting point give one point on the curve, the other two of which are the melting points of pure copper and pure bismuth.

A general view of the apparatus is seen on Figure 3.

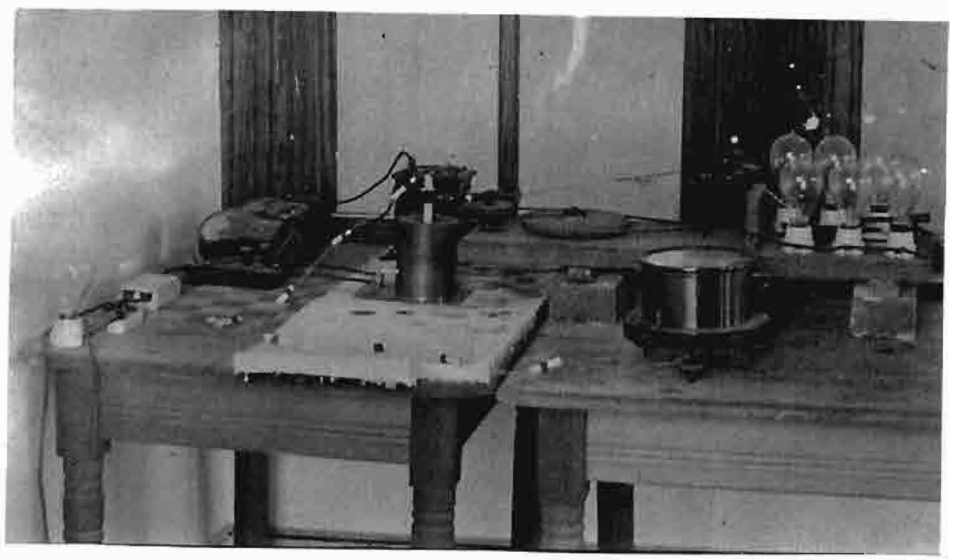


Fig. 3.

A 90% Cu 10% Bi, alloy was made by first melting the copper under a layer of charcoal, to prevent oxidation, and then adding the bismuth. A pyrometer was inserted and started stirring. It registered a temperature of 1010 degrees Centigrade when the current was cut off and the furnace allowed to cool.

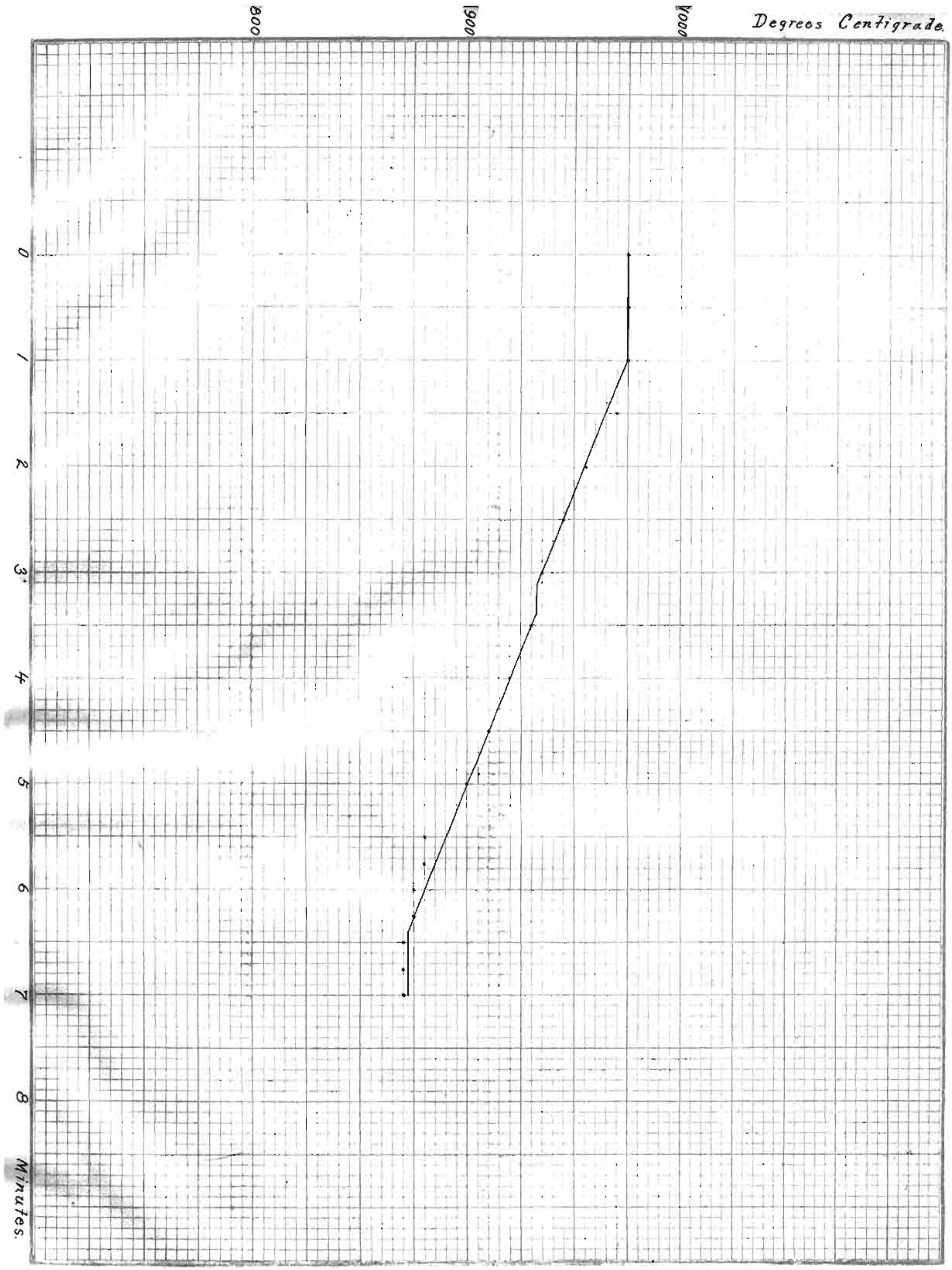
The temperature, time, readings follows:

Time		Temperature	
11.01		975degrees Cent.	
	1/2	975	"
11.02		975	"
	1/2	970	"
11.03		955	"
	1/2	945	"
11.04		935	"
	1/2	930	"
11.05		920	"
	1/2	910	"
11.06		900	"
	1/2	880	"
11.07		875	"
	1/4	875	"
	1/2	870	"
	3/4	870	"
11.08		870	"

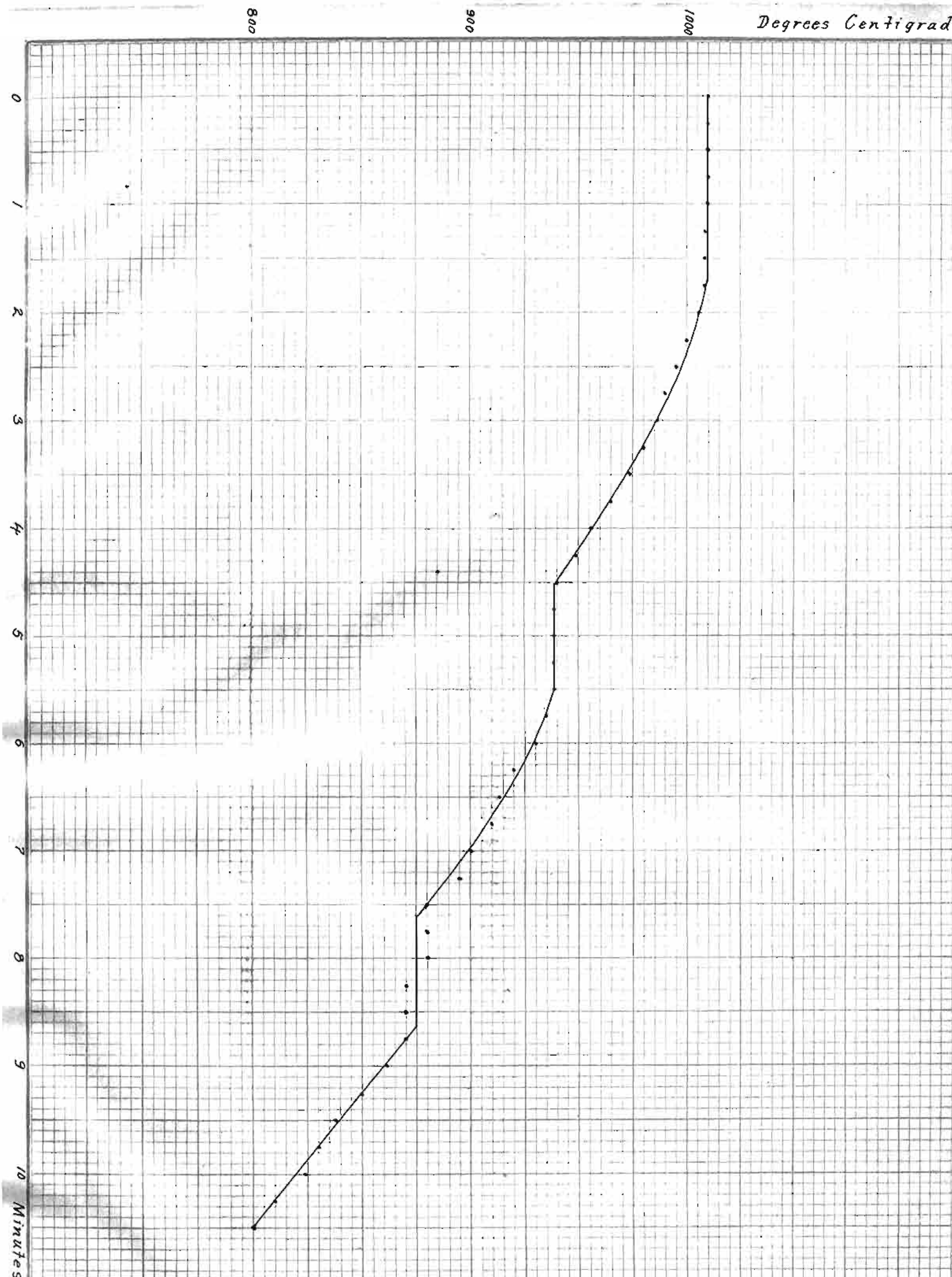
Curve 1.plotted from these observations.

Time		Temperature
11.20		1010
	1/4	1010
	1/2	1010
	3/4	1010
11.21		1010
	1/4	1008
	1/2	1008
	3/4	1008
11.22		1006
	1/4	1000
	1/2	995
	3/4	990
11.23		987
	1/4	980
	1/2	973
	3/4	965
11.24		957
	1/4	948
	1/2	940
	3/4	938
11.25		938
	1/4	938
	1/2	938
	3/4	935
11.26		930
	1/4	920
	1/2	913
	3/4	910
11.27		900
	1/4	895
	1/2	880
	3/4	880
11.28		880
	1/4	870
	1/2	870
	3/4	870
11.29		862
	1/4	850
	1/2	838
	3/4	830
11.30		823
	1/4	810
	1/2	800

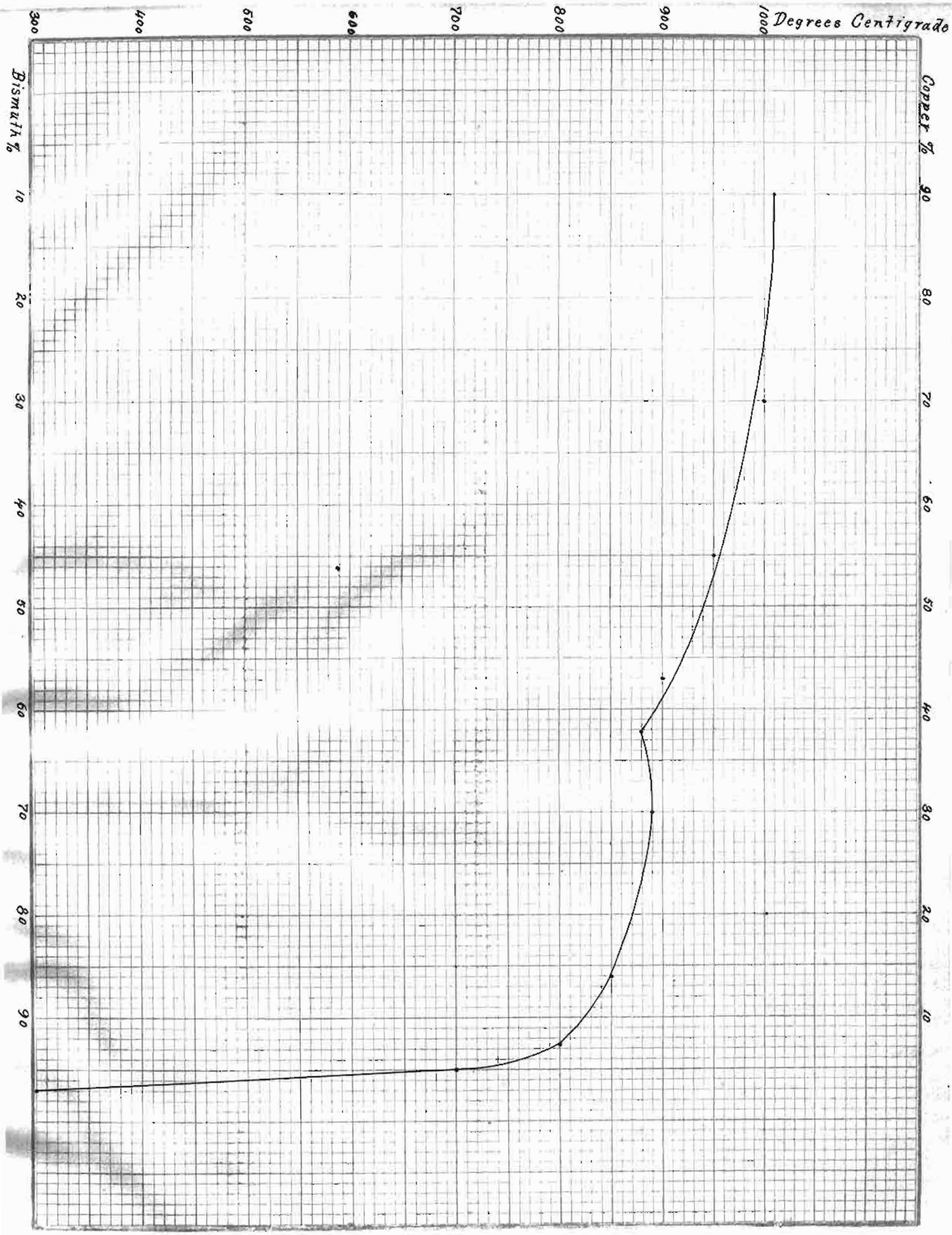
Curve 2. plotted from these observations.



Curve I.



Curve II.



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Curve III.

From the break which occurs in Curve 2. we may conclude that until a temperature of 880 degrees is reached only pure copper has been separating; the bismuth alloys with some of the copper,remaining in solution. The second break probably marks the solidifying point of this alloy. The subsequent regular lowering of the temperature,the cooling of the now solid mass.

Comparing these observations with those of Prof. Roberts-Austen in "An Introduction to the Study of Metallurgy",page 114, his curve is plotted as Cruve 3. We find that this alloy which separates out is brobably Cu 38 %,Bi 62 % .

In the crucible in which my experiment was made there was not enough molten alloy to permit a sample of it to be taken for analysis.

I next directed my attention to the determination,of whether bismuth as an impurity in copper formed a definite compound or distributed itself between the crystals of pure copper,thus reducing its electrical conductivity and increasing its brittleness. As this is to be done by means of measurements taken from the sectional areas of pure copper relative to those of the alloy. I prepared nine specimens containing percentages of bismuth and copper as in the following table.

	%	Wgt.in grams of constituents.	Wgt.of specimen after melting.	Wgt.lost	No
Cu	100.	37.0957	35.9500	1.1457	9
Cu	99.99	39.9960	39.9235	.0765	8
Bi	.01	.0040			
CU	99.97	33.09007	33.0270	.0730	7
Bi	.03	.00993			
Cu	99.95	40.87955	40.7355	.1645	6
Bi	.05	.02045			
Cu	99.90	40.7592	40.7200	.0800	5
Bi	.10	.0408			
Cu	99.85	39.37410	39.3405	.09275	4
Bi	.15	.05915			
Cu	99.80	40.0198	40.0028	.0972	3
Bi	.20	.0802			
Cu	99.75	39.8202	39.8235	.0965	2
Bi	.25	.0998			
Cu	99.00	34.0857	34.0400	.0900	1
Bi	1.00	.3443			

Each specimen was made by placing its weighed amount of copper in an annealing cup covered with a thick layer of charcoal in an electric furnace. The cover of which was kept closed to render the atmosphere around the copper as nearly as possible a reducing one. Care was also taken to keep the copper covered with charcoal.

As soon as the copper became molten the weighed amount of bismuth was dropped into it and the molten alloy stirred with a pipe stem. The crucible containing the molten metal taken from the furnace was allowed to cool in the atmosphere and as soon as solid immersed in water. Each specimen was made under precisely the same conditions. The large loss in the weight of specimen 9 is due to the first melt having been poured into a porcelain mold which broke and spilled some of the molten metal.

The effect of bismuth on copper is in a small degree illustrated by the surface of the specimens, as seen on Fig. 4.

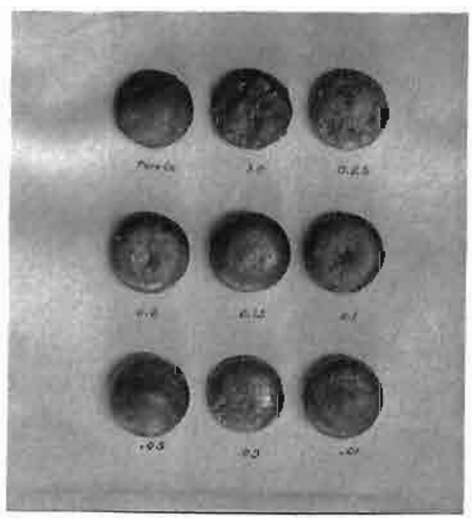
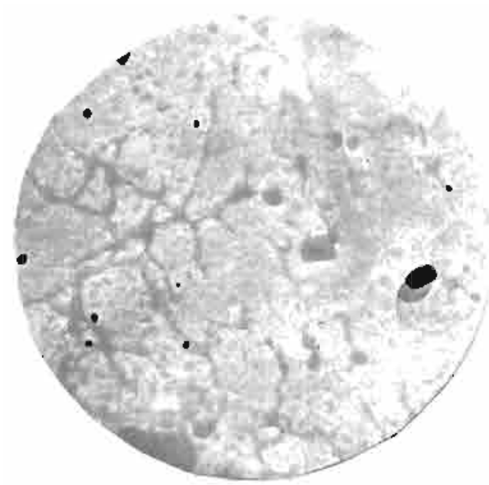


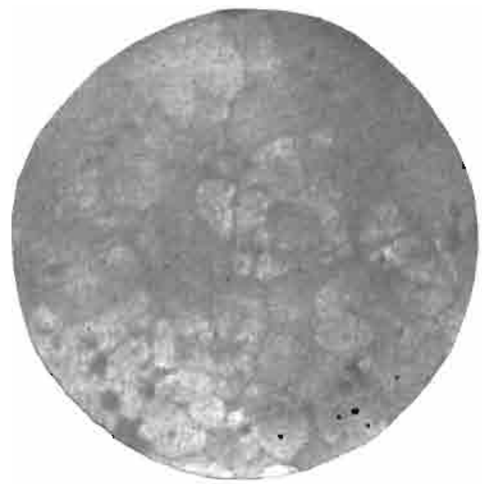
Fig. 4.

The surface of the pure copper is smooth; that of the specimens containing 1% Bi quite crystalline, and this crystallinity decreases as the % of bismuth decreases.

Traverse

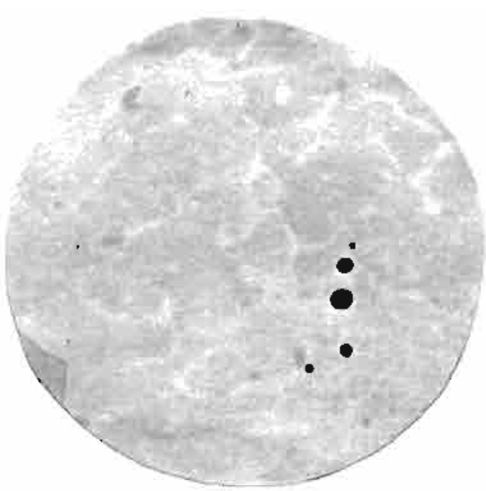


Longitudinal

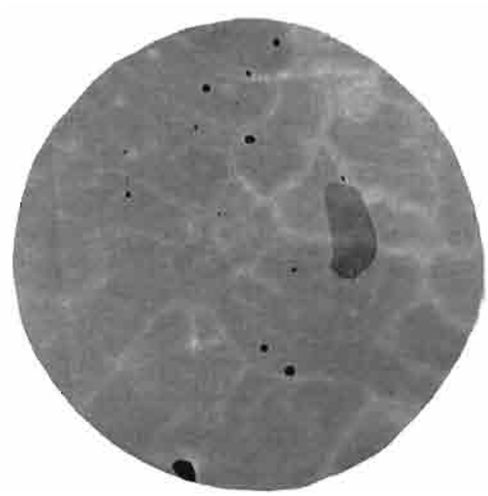


Bismuth 1 %

Traverse



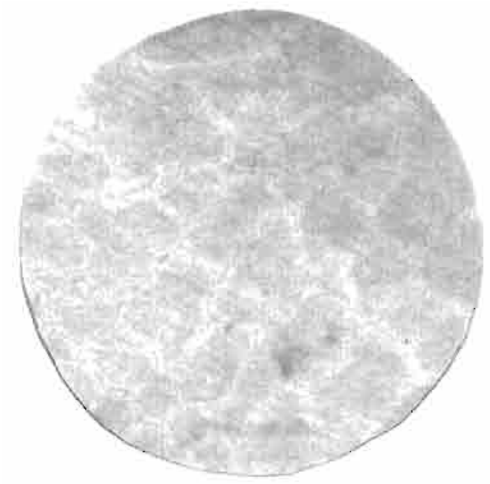
Longitudinal



Bismuth .25 %

Traverse

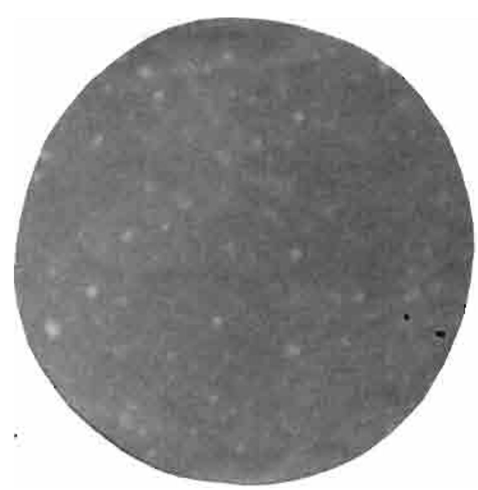
Longitudinal



Bismuth .2 %

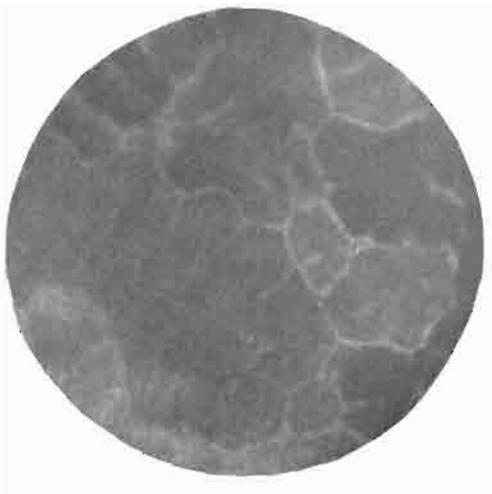
Traverse

Longitudinal

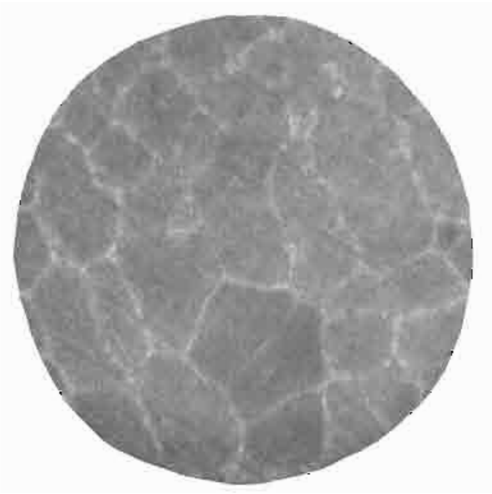


Bismuth .15 %

Traverse



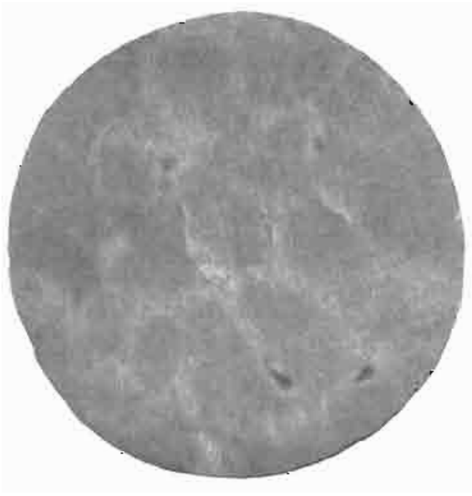
Logitudinal



Bismuth .1 %

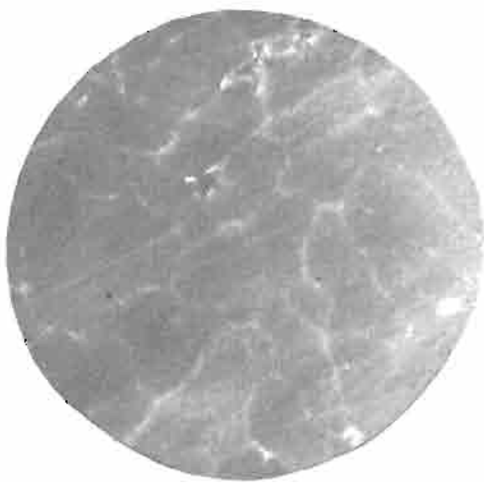
Traverse

Longitudinal

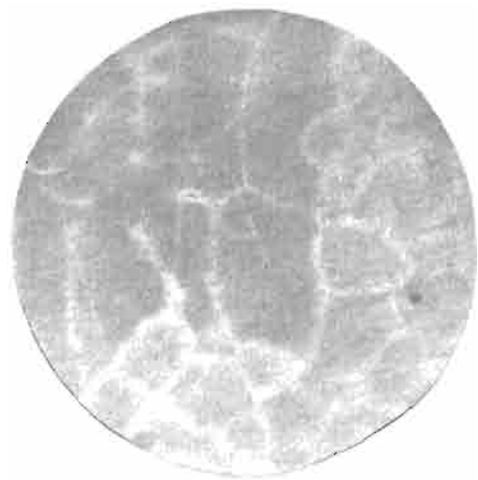


Bismuth .05 %

Traverse



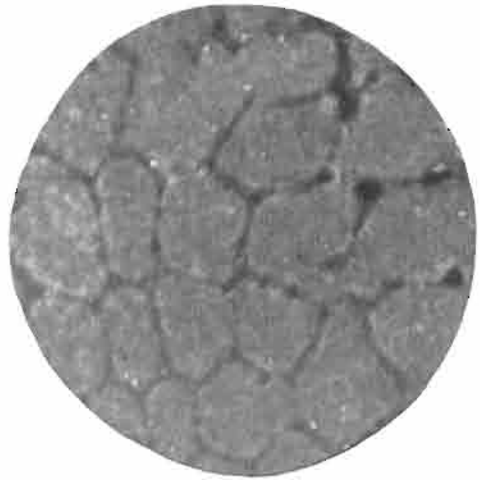
Longitudinal



Bismuth .03 %

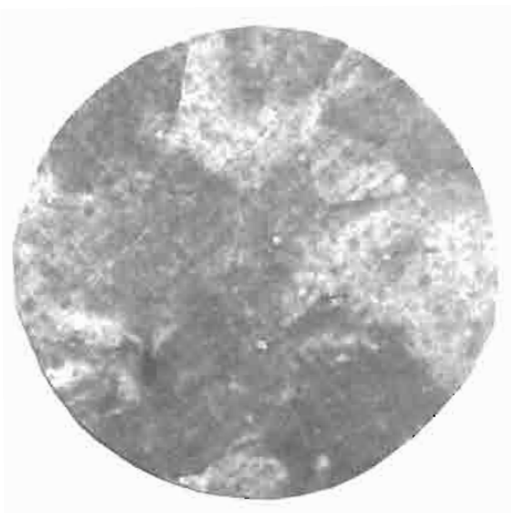
Traverse

Longitudinal

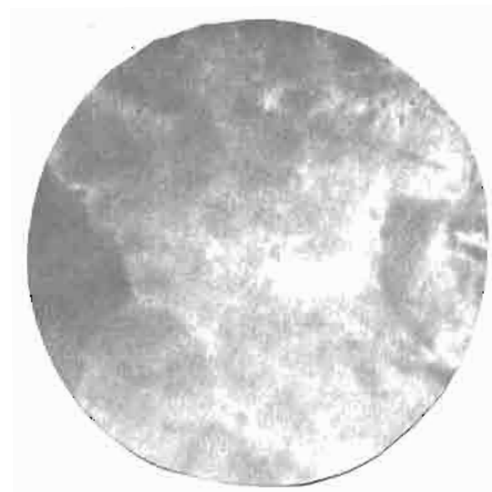


Bismuth .01 %

Traverse



Longitudinal



Pure COPPER.

Time has not permitted me to finish this thesis as was at first intended. I hope to be able, at some future time, to make the necessary measurements of the foregoing plates.

Respectfully,

S. M. Greenidge.