the filtrate to first appearance of a scum, taking up with a little hydrochloric acid and water and filtering, carrying the blank, or dummy, test to the same length. Sixty-two tests (5 cc. free acid, one-half hour's boiling) showed as follows :

| | | | |
|---|---|---|---|
| Number of tests in which | precipitation was complete | | 9 |
| " " " " " | 0.001 to 0.002 per cent. | was found in filtrate | 34 |
| " " " " " | 0.003 to 0.004 " | " " " " | 11 |
| " " " " " | 0.005 to 0.008 " | " " " " | 8 |

In these losses are included also the barium sulphate dissolved by the hydrochloric acid wash used to free the precipitate from iron.

In these tests the sulphur percentage ranged from 0.015 to 0.09 per cent. The amount of sulphur unprecipitated does not depend upon the total amount—may be little in high sulphur steels and *vice versa*. So it is advisable in all cases to make a plus correction in the result of at least 0.002 per cent.

In Blair's " Chemical Analysis of Iron " the warning is given that the use of aqua regia in dissolving the drillings seems to result in loss of sulphur. Nevertheless it is necessary to use some little hydrochloric acid in the case of high carbon steels toward the end to effect complete solution. The following results obtained in the regular course of work were suspected of being low and the determinations were repeated, using the hydrochloric acid more sparingly :

| No. | First determination. Percentage of sulphur. | Repeated, using HCl more sparingly. Percentage of sulphur. |
|---|---|---|
| 609 | 0.005 | 0.013 |
| 611 | 0.004 | 0.011 |
| 814 | 0.014 | 0.020 |

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[CONTRIBUTION FROM THE JOHN HARRISON LABORATORY OF CHEMISTRY, NO. 55.]

## ALLOYS MADE IN THE ELECTRIC FURNACE.

BY LEWIS P. HAMILTON AND EDGAR F. SMITH.

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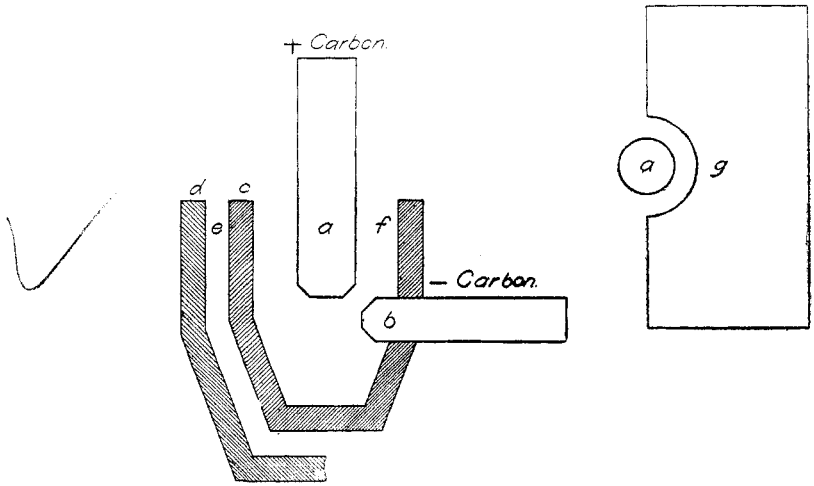
DURING the past year various alloys were made by us. We desire here to give a sketch of the furnace in which they were produced, and also to briefly describe the products, as they possess interest and perhaps value.

## THE FURNACE.

The + carbon *a* is of convenient length and 2 cm. in diameter; the — carbon *b* is 1.5 cm. in diameter, while *c* represents a No. 1 Dixon graphite crucible, which has an interior width of 5 cm. and a depth of 7 cm. It was placed in *d*, a second graphite crucible, 1 decimeter across the top. The space, *e*, between the




two crucibles, was filled with magnesia. *g* is one of two carbon plates, 1.5 cm. in thickness, which served as a cover.

It is absolutely necessary that the carbon, *b*, should make a good contact with the crucible, *c*, to avoid the formation of an arc at their juncture which would destroy the crucible. The carbon is inserted in the crucible at about 3 cm. from the bottom. To obtain products free from carbon, *c* is lined with magnesia.

## OPERATION.

The material to be melted was introduced into the crucible until it was about even with the carbon, *b*, and then the arc was started between the two poles by means of a thin pencil of carbon. The crucible was next covered in part by *g* and the remainder of the material was introduced from time to time until 150 to 200 grams had been added. The cover, *g*, was then adjusted and the current allowed to run for a while longer. The full period of action was usually ten to fifteen minutes.

The current used in the fusions equaled from 145 to 165 amperes, and from 25 to 70 volts, although the average voltage was 35.

ALLOYS.

1. This first alloy contained copper, tungsten, iron, and gangue. It was made by fusing together commercial copper and a tungsten matte which had been previously obtained by reducing the mineral wolframite in the furnace with carbon. It was lighter in color but very much harder than ordinary copper ; indeed, it proved to be the hardest of the copper alloys. Its specific gravity was found to be 7.98. Its analysis showed 66.88 per cent. of copper, 23.03 per cent. of tungsten, 5.74 per cent. of iron, and 5.04 per cent. of gangue.

2. A matte of titanium was first prepared by reducing 100 grams of rutile with 15 grams of carbon and fusing the product with copper. The alloy had a brass-like appearance ; it was tough but not so hard as the preceding product, and its specific gravity equaled 7.616. It gave, upon analysis, 90.98 per cent. of copper, 3.12 per cent. of titanium, 3.51 per cent. of silicon, and 2.08 per cent. of carbon.

3. The mineral columbite was reduced with carbon in the furnace, and the resulting matte then fused with metallic copper. The product did not differ in appearance very much from metallic copper. Its specific gravity was 8.38.

ANALYSIS.

| | Per cent. |
|---|---|
| Copper | 95.01 |
| $Cb_2O_5 + Ta_2O_5$ | 2.01 |
| Gangue | 2.57 |
| | 99.59 |

4. Metallic copper and a molybdenum matte were fused together. The alloy, grayish red in color, was much harder than copper, but not so hard as the alloy of copper and tungsten. Its specific gravity was 7.934.

ANALYSIS.

| | Per cent. |
|---|---|
| Copper | 78.53 |
| Molybdenum | 8.53 |
| Iron | 2.71 |
| Carbon | 2.42 |
| Gangue | 8.02 |
| | 100.21 |

5. Chromium oxide and metallic copper were fused in a carbon crucible. The product was gray-red in color, and in hardness stood next to the alloys containing tungsten and molybdenum. Its specific gravity equaled 8.3146.

ANALYSIS.

| | Per cent. |
|---|---|
| Copper | 88.18 |
| Chromium | 3.22 |
| Iron | 1.35 |
| Carbon | 2.38 |
| Gangue | 4.13 |
| | 99.26 |

6. A tungsten matte was fused down with equal parts of metallic copper and aluminum, giving an alloy yellow in color, which showed the following composition :

ANALYSIS.

| | Per cent. |
|---|---|
| Copper | 34.11 |
| Aluminum | 24.89 |
| Tungsten | 32.67 |
| Iron | 2.12 |
| Gangue | 6.56 |
| | 100.35 |

7. Ten grams of metallic iron, 10 grams of titanium matte, and 10 grams of commercial metallic tungsten were fused together. Six to 8 grams of ferric oxide were added during the fusion. The product was steel-gray in color, of specific gravity 6.707, and gave the following :

ANALYSIS.

| | Per cent. |
|---|---|
| Iron | 82.15 |
| Titanium | 7.28 |
| Tungsten | 1.66 |
| Gangue | 6.63 |
| Carbon | 2.30 |
| | 100.02 |

8. An alloy of iron, chromium, and titanium was made precisely like the preceding example. It was steel-gray in color with a very distinct fracture, and the specific gravity 6.464.

ANALYSIS.

| | Per cent. |
|---|---|
| Iron | 76.41 |
| Chromium | 16.29 |
| Titanium | 2.47 |
| Silicon | 2.39 |
| Carbon | 3.14 |
| | 100.70 |

By greatly increasing the quantity of chromium in the fusion a product was obtained which had the following composition :

ANALYSIS.

| | Per cent. |
|---|---|
| Iron | 53.03 |
| Chromium | 40.37 |
| Titanium | 2.65 |
| Gangue | 4.33 |
| | 100.38 |

9. The matte resulting from the reduction of 100 parts of columbite and 15 parts of carbon, in the electric furnace, was fused down with an excess of metallic iron. The product was brittle and steel-gray in color.

ANALYSIS.

| | Per cent. |
|---|---|
| Columbium | 59.76 |
| Tantalum | 18.77 |
| Iron | 15.73 |
| Gangue | 5.12 |
| Tungsten | 0.63 |
| | 100.01 |

10. A matte of columbium and tantalum, a matte of titanium from rutile, and an excess of metallic iron were fused in the furnace and yielded an extremely hard, gray-colored alloy, which analyzed as follows :

ANALYSIS.

| | Per cent. |
|---|---|
| Iron | 80.03 |
| Columbium | 10.15 |
| Tantalum | 2.91 |
| Titanium | 3.18 |
| Carbon | 1.99 |
| Silicon | 2.14 |
| | 100.40 |

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