$3CaO.Al_2O_3$ and $5CaO.3Al_2O_3$ have higher indices of refraction than they have in the binary system.

The fields in which CaO, $3CaO.Al_2O_3$, $5CaO.3Al_2O_3$, $4CaO.Al_2O_3.$-Fe_2O_3 and solid solutions of $4CaO.Al_2O_3.Fe_2O_3$ and $2CaO.Fe_2O_3$ separate as primary phases from these ternary melts are shown diagrammatically.

WASHINGTON, D. C.

[CONTRIBUTION FROM THE RESEARCH LABORATORY OF ORGANIC CHEMISTRY, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, No. 21]

A RESISTANCE WIRE TO BE USED IN THE CHEMICAL LABORATORY

BY JEAN PICCARD

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Resistance coils which must have a perfectly constant resistance are always made of constantan (identical with ideal) or of manganin, as the resistances of both alloys are nearly independent of the temperature. These wires corrode easily. Nevertheless, the bad surface quality due to this corrosion causes no inconvenience since the whole coil is protected by paraffin. The very low thermoelectric force of manganin against copper renders its use almost imperative whenever direct current is involved. The somewhat better surface qualities of constantan are more than offset by its exceptionally high thermoelectric force against copper.

If, however, a measuring wire with slide contact is needed, as in the Wheatstone Bridge, then one faces an entirely different problem. One does not need in this case the very low temperature coefficient of the resistance because the different parts of the wire have nearly the same temperature, but one needs a wire with a bright surface which is not attacked either by the air or by the acid fumes of the laboratory. For this reason many authors favor the use of platinum wire. Its surface remains always perfectly clean, but its electric resistance has too high a temperature coefficient. It increases by 30 to 40% if the temperature rises from 0 to 100°, so that even the small changes of temperature which one produces when moving the contact slide with the hand have a noticeable effect on the position of the zero point.

The best resistance wire for Wheatstone Bridges, which, on request, was offered by Hereus for the use in the chemical laboratory, is platin-iridium. Apart from its very high price, however, it still has too high a temperature coefficient. An American company which manufactures resistance wires as a specialty was also unable to make us any satisfactory offer.

The question arose as to whether one could not replace the copper in constantan (60% Cu + 40% Ni) by the more noble metals of the same group, silver or gold. Since the jewelers recently began to use nickelgold alloys called white gold, our first experiments were made with four of these alloys found on the market. One of them, a 14 K. white gold, was found to replace most favorably the constantan or the platinum measuring wire of the Wheatstone Bridge. Its electrical, chemical and mechanical properties make it a nearly ideal alloy for our purpose, especially if one is working with alternating current, as one generally is in the chemical laboratory. Its thermoelectric force against copper, although only half as large as that of constantan, is still too large to allow the substitution of manganin by the new alloy if very accurate measurements have to be made with direct current.

From a mechanical point of view, too, the new gold alloy has remarkably fine qualities. It is easy to pull thin wires of it; the alloy is hard enough to eliminate all abrasion at the contact point and it has an exceptionally high tensile strength, about 125 kg./sq. mm. This is four times more than constantan, even more than ordinary steel wire. One has, of course, a great advantage in being able to pull a measuring wire quite tightly without fear of breaking it.

The following table contains some of our results.

Table I

Effect of Chemicals

	Ammonia	Concd. HCl	Concd. HNO_3
Constantan	Corrodes quickly	Dissolves slowly	Dissolves rapidly
14 K. white gold	No action	No action	Extracts Ni and Cu
18 K. white gold	No action	No action	No action

Electric Qualities

	Resistance, $10^4 \rho$	Temp. coefficient, $10^{-4} \cdot \frac{1}{\rho} \cdot \frac{d\rho}{dt}$	Thermoelectric force against copper, M. V./100°
Platinum, c. p.	0.126	38.0	−0.75
Constantan	.49	0.2	+4.5
14 K. white gold	.42	2.2	+2.6
18 K. white gold	.38	4.2	+3.82

The question further arose whether or not this temperature coefficient of 2.2 of the 14 K. white gold would still be too high to allow the use of the alloy for our purpose. This question was solved in the following way. A Wheatstone Bridge was constructed with a 100cm. long measuring wire of ordinary platinum, the temperature coefficient of which was 25, that is, more than 10 times that of the 14 K. white gold. When the zero point was about in the middle of the measuring wire, one side of the wire was touched with the hand and the displacement of the zero point observed. Then a radiator was turned on, on one side of the bridge or, the outside temperature being at freezing, a window was opened so that the draft came sideways onto the measuring wire. The zero point was of course displaced but even under these extreme conditions the displacement was never more than 1 mm. Hence with the 14 K. white gold wire used under these conditions the faults would always have been less than 0.1 mm. That means that under ordinary conditions or even under bad conditions the temperature coefficient of the 14 K. white gold measuring wire will never be the cause of any noticeable error.

Summary

White gold,[1] which has already partially replaced platinum in jewelry, replaces it advantageously in the alternating current Wheatstone Bridge when the latter is used in a chemical laboratory where constantan corrodes too rapidly. Constantan, exposed to the air of the laboratory, had to be cleaned after a few weeks, while white gold still gave perfectly good contacts after ten months.

Good surface qualities of the measuring wire are of the greatest importance, especially in modern laboratory technique where amplifiers are used in connection with very weak currents.

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[CONTRIBUTION FROM THE T. JEFFERSON COOLIDGE, JR., MEMORIAL LABORATORY, HARVARD UNIVERSITY]

A REVISION OF THE ATOMIC WEIGHT OF TITANIUM. III THE ANALYSIS OF TITANIUM TETRABROMIDE

BY GREGORY PAUL BAXTER AND ALBERT QUIGG BUTLER

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In two recent papers[1] the purification and analysis of titanium tetrachloride are described. The atomic weight of titanium computed from the experimental results is 47.90, a value considerably lower than that obtained by Thorpe, 48.1, which has been in use for some time. As a check on our recent work we have prepared and analyzed pure titanium tetrabromide and have obtained the same value as that found by analysis of the tetrachloride. Although in outline the two methods are similar, yet the differences in the physical and chemical properties of the compounds involved make it improbable that both results are affected by constant errors to the same extent.

Purification of Materials

Water, nitric acid, silver and bromine were purified by the methods usual when extreme refinement is necessary.[2]

Carbon was prepared from rock candy crystals, by charring, followed

[1] 14 K. white gold wire similar to the one described above can now be obtained from Baker & Co., Inc., Newark, N. J.

[1] (a) Baxter and Fertig, THIS JOURNAL, **45**, 1228 (1923); (b) Baxter and Butler, *ibid.*, **48**, 3117 (1926).

[2] See, for instance, Baxter and Grover, *ibid.*, **37**, 1028 (1915).