Pyrometer Protection Tubes

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(Chicago Meeting, September, 1919)

IT is intended to discuss in this paper the protection appliances used for high-temperature pyrometer installations involving the use of platinum couples and describe some of the characteristics of a new carborundum protection tube. Of all the components that go to make a complete pyrometer installation, the one given the least attention and the one about which there is the least exact information is the outer protection tube. This condition is unfortunate as much, and in some cases even the success of the equipment as a whole, depends on the proper type of protection. In the majority of cases, the installation is allowed to operate without attention until some part of the apparatus breaks down. The outer tube is the component that usually fails and, more often than not, the failure causes breakage of the porcelain protection and ruin of the couple. This condition should be recognized and studied as it has a very important bearing upon the upkeep cost of pyrometer equipment. The cost of the outer protection tube is small compared with the cost of the platinum couple and procelain protection and it would well repay users of this type of equipment to replace their outer protection tubes at certain definite periods, which experience shows is necessary to prevent destruction of the platinum.

Speaking generally, platinum thermocouple equipment is used for measuring temperatures over 2000° F. (1094° C.), and is used extensively for the control of brick and pipe kilns, glass pot furnaces, glass tank furnaces, heat-treating furnaces, open-hearth furnaces, and forge furnaces. A satisfactory protection tube must be sufficiently refractory not to soften at the maximum temperature within the furnace. It must be resistant to cracking due to temperature changes, should be as nearly gas-tight as possible, and should be made of a material with a high thermal conductivity and great resistance toward erosion by the furnace atmosphere.

Carborundum is a refractory that possesses these characteristics to a marked degree. Recent manufacturing improvements have made pos-

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sible the production of protection tubes composed entirely of carborundum without the addition of any binding material. These tubes possess all the desirable properties of carborundum including great refractoriness, low coefficient of expansion, resistance toward the action of furnace gases and slags, and high thermal conductivity. The effect of the thermal conductivity of the protection tube is of great importance and has a very decided bearing on the accuracy with which the pyrometer temperature indication follows the actual temperature condition within the furnace. Carborundum having a thermal conductivity of about eight times that of fireclay and three to four times that of fused alumina refractories would be expected, when used as a protection, to show a considerable advantage in this respect.

To prove this point a series of experiments was conducted with carborundum and fireclay tubes to determine the lag in the pyrometer reading caused by these types of protection. Four chromel-alumel type *P* couples were prepared and standardized. The first couple was used in the form of bare wire without any protection, the second was protected by a porcelain tube and a carborundum tube 1 in. (2.5 cm.) inside diameter, 1⅞ in. (4.7 cm.) outside diameter, length outside 19 in. (47 cm.), length inside 17¾ in. (45 cm.); the third was protected by a porcelain tube and a fireclay tube 1 in. inside diameter, 2 in. outside diameter, length outside 18 in., length inside 17¼ in., and the fourth couple was protected by a porcelain tube and a fireclay tube 1⅛ in. inside diameter, 3 in. outside diameter, length outside 18 in., length inside 17⅛ in. A large electric pot furnace was maintained at a constant temperature by means of a rheostat. The temperature of this furnace was determined by means of a platinum thermocouple, which was allowed to remain in the furnace throughout the experiment.

Experiment 1.—The furnace was maintained at approximately 450° C. and the four chromel-alumel couples were plunged into it, one at a time, and allowed to remain there until the millivolt reading of the couple became constant. Readings of millivolts and time were taken and curves plotted.

Experiment 2.—The procedure was repeated with the furnace temperature maintained at approximately 950° C. The following results were obtained:

	Furnace at 450° C., Minutes	Furnace at 950° C., Minutes
Time for reading of bare couple to become constant	5	2½
Time for reading of couple in carborundum protection to become constant	25	12½
Time for reading of couple in 2 in. diameter fireclay protection to become constant	50	35
Time for reading of couple in 3 in. diameter fireclay protection to become constant	70	50

It was recognized that while the above results were interesting they did not indicate what could be expected from commercial installations where changes of temperature were less rapid. As measuring the temperature of the gases of the open-hearth steel furnace is a promising field for pyrometry, it was decided to make certain tests to determine the effect of couple protection on this work. Three calibrated platinum thermocouples were installed side by side in the slag pocket of an open-hearth

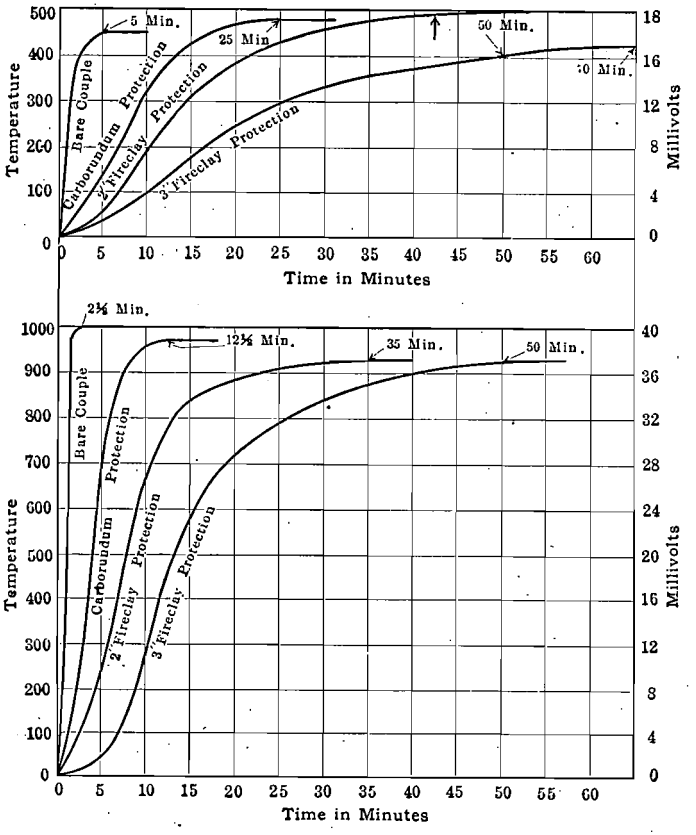

FIG. 1.—CURVES SHOWING LAG IN PYROMETER READING FOR DIFFERENT PROTECTION TUBES.

steel furnace just above the checkerwork. The first couple had procelain and a 1⅞ in. diameter carborundum-tube protection, the second had porcelain and a 2 in. diameter, fireclay-tube protection, and the third couple had porcelain and a 3 in. diameter fireclay-tube protection. Leads and switches were arranged so that any one of the couples could be connected with a millivolt meter. Readings were taken of millivolts and time for each couple for seven reversals of the furnace gases. The

thermocouple protected by the 2-in. fireclay tube did not operate satisfactorily throughout the entire test and no curve of the readings of the couple is included. The general shape of the curve was the same as that

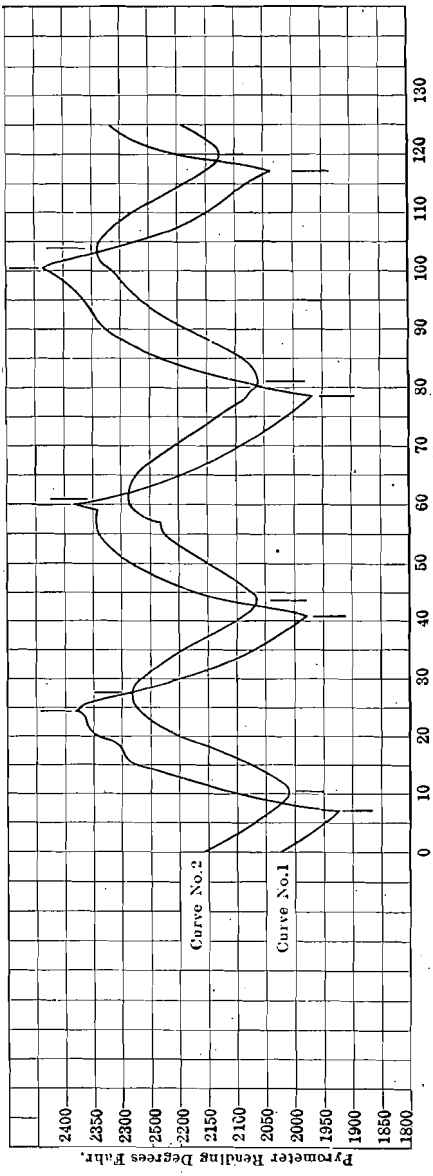

FIG. 2.—CURVES SHOWING TEMPERATURE VARIATIONS OF SLAG POCKET OF OPEN-HEARTH FURNACE. Curve No. 1, couple protected by 1⅞ in. carborundum tube. Curve No. 2, couple protected by 3-in. fireclay tube.

of the couple protected by the 3-in. fireclay tube, the time and temperature lag being less. The average results for this thermocouple are included in the tabulated data. No record was made of the exact time of

changing the valves on the furnace so that no data is available to show the time lag of the couple protected by the carborundum tube. However judging from the shape of the curve for this couple the time lag must have been small. The following data are obtained from the curves shown in Figs. 1 and 2.

Reversal	Indicated Time of Reversal by Couple with		Lag of 3-in. Fireclay Behind Carborundum, Minutes	Indicated Temperature at Time of Reversal by Couple with		Temperature Lag of 3-in. Diam. Fireclay Couple as Compared with Carborundum Couple, Degrees F.
	Carborundum Protection, Minutes	3-in. Fireclay Protection, Minutes		Carborundum Protection, Degrees F.	3-in. Fireclay Protection, Degrees F.	
1	7	10½	3½	1923	2010	87
2	24½	27½	3	2382	2282	100
3	40¾	44	3¼	1978	2065	87
4	60	61	1	2385	2288	103
5	78½	81	2½	1962	2062	100
6	100½	104	3½	2435	2340	95
7	117	120	3	2037	2125	88

	Fireclay Protection Tube	
	3 Inch	2 Inch
Average time lag of couple protected by fireclay tube over carborundum protected couple	2 min. 49 sec.	1 min. 9 sec.
Average temperature lag of couple protected by fireclay over carborundum protected couple	94.3° F.	56.0° F.

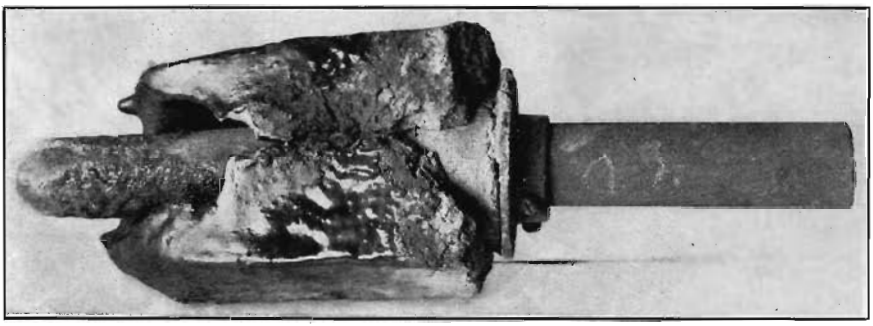

Fig. 3.—Carborundum tube after 4 mo. service in an oil-fired glass tank furnace.

It will be seen from these results that the use of couple protecting material having high heat conductivity is of very considerable importance.

In the glass-furnace field carborundum tubes are rapidly becoming the standard type of protection. In Fig. 3 is shown a photograph of a carborundum tube that has had 4 mo. service in an oil-fired glass tank furnace. It will be noticed that the fireclay supporting tube has been very badly melted away while the carborundum tube shows only slight

signs of wear. A life from 6 to 8 mo. is usual for these tubes and it is not uncommon to find them giving satisfactory service for a very much longer period.

Due to the high thermal conductivity of carborundum tubes it is not necessary, when installing this equipment, to allow the tube to project more than a short distance into the furnace. In some cases it is even desirable to keep the end of the tube flush with the furnace wall; this method of installation will add very materially to the life of the thermocouple protection.