SOME OBSERVATIONS ON THE PROPERTIES OF CERTAIN SO-CALLED THERMAL INSULATORS.

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It is often necessary in laboratory practice to employ some thermal insulating material as covering for vessels to prevent excessive loss of heat when it is desirable to maintain the contents at a fairly constant temperature.

Many common substances, such as paper, cotton felt, wool felt, wood pulp, and asbestos, are useful for this purpose. One of the most frequently used materials is asbestos in some form, such as fiber, sheet or

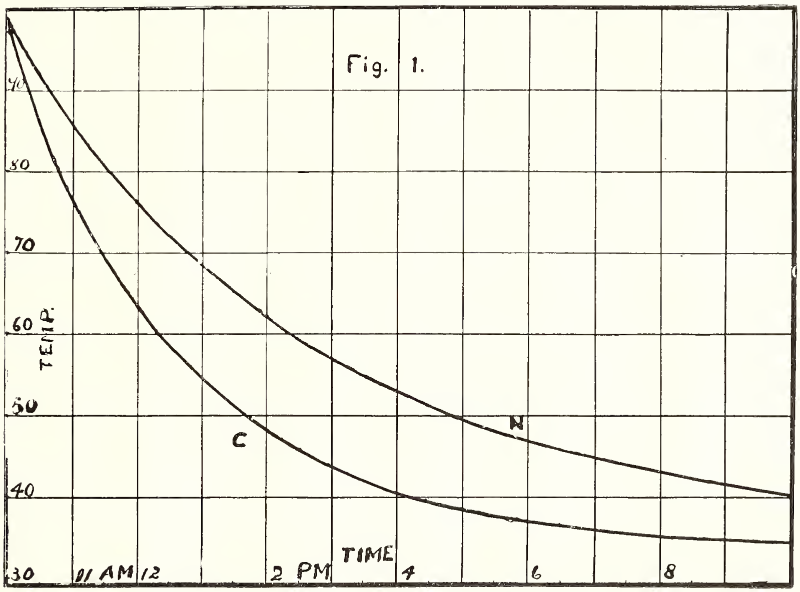

Fig. 1—Diagram of time and temperature results plotted from results reported in Table I.

paper. Asbestos paper is thin sheet, quite flexible and may be applied to a surface in one or more layers with little trouble. Merely wetting the sheet and applying it to a surface, like wallpaper, gives without use of any paste a fairly permanently adhesive coating, provided the surface is hot.

The object of these observations was to determine the effect of putting a layer of this paper on the exposed surfaces of vessels containing hot liquids or gases. Two sections of fairly bright tin downspouting, each four inches in diameter and 24 inches long, were fitted

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with bottoms and covers. These were set about 12 inches apart in a basement room and protected from drafts. Each vessel was filled with the same mass of boiling water. The water was stirred and the temperatures noted at frequent intervals until the temperature of each was nearing that of the room, which did not vary more than one and one-half degrees throughout the entire time. As the vessels and their contents cooled the difference in the temperatures of the two at no time was greater than 1.25° and most of the time the thermometers read practically the same.

TABLE I.—Temperature Records of Covered and Uncovered Vessels.

Time	Temp. Room	Temp. C (covered)	Temp. N (uncovered)	Excess
10:00	26	99.1	99	—0.1
11:00	26.5	76.2	85.3	9.1
12:00	27	63	75.7	12.7
1:00	27.1	54.6	68.1	13.5
2:30	26.5	45.8	59.2	13.4
3:00	26.1	43.9	56.8	12.8
4:00	26.3	41	53	12
6:00	27	37	46.9	9.9
8:00	27.5	35.1	43	7.9

One vessel (N) was left naked and the other (C) was covered with a single layer of the asbestos paper. When the covering was thoroughly dry the vessels were again filled with hot water and allowed to cool as before. The water in each was continually stirred and temperatures taken at stated intervals. Table I shows some of the readings obtained and figure 1 shows the result of plotting time and temperatures. These are merely the ordinary cooling curves and show the temperature of each at any time during the cooling process.

A pair of much larger vessels were tested in the same manner. Table II, made up of readings selected at random from a very large list taken during the cooling of the covered (C) and naked (N) vessels, will show the results.

Each of the pair of smaller vessels was equipped with a heating coil of nichrome wire. These coils had the same resistance, and when

TABLE II.—Temperature Records of Covered and Uncovered Vessels

Time	Temp. Room	Temp. C (covered)	Temp. N (uncovered)	Excess
11:52	24	99.5	99.6	.1
12:41	24	91.2	92.3	1.1
1:05	23.3	84	88.3	4.3
1:45	24	77.5	83.2	5.7
2:45	24	69	76.5	7.5
3:15	24.1	66	74	8
4:00	24	61.1	69.8	8.7
4:42	23.8	55	66.2	11.2
5:22	24	53.8	63	9.2

Size of vessels, Diameter = 7.35 in., Length = 38.6 in.

connected in series would have the same current and therefore the same quantity of heat generated in each vessel.

By trial a current value was found which would maintain the naked vessel filled with water at 85° to 86° C. in a room whose temperature was 27° C. This equilibrium could be maintained for an hour. The covered vessel, in the meantime, maintained an equilibrium at a temperature of but 77° C. The water in both vessels was stirred at regular intervals and precaution was taken to prevent escape of vapor.

An effort was then made to find the respective currents required to maintain each vessel at the same temperature and in equilibrium in a room whose temperature was maintained at 27° C. A common temperature of 79° to 80° C. was maintained in each for more than 90 minutes. To do this required a current of 7.2 amperes in the coil of the naked vessel, while 8.1 amperes were required for the other. Since the heat developed by each coil is proportional to the square of the current in it, we see that over 24 per cent more heat was required to maintain the covered vessel at the given temperature than was required for the naked one.

Two sections of furnace pipe used to convey hot air were obtained. These were made of bright tin and were six feet long and nine inches in diameter. The ends were closed and all seams and joints were made tight. Each was equipped with a heating coil of nichrome wire which extended nearly the full length of the pipe parallel to but somewhat below the central axis when the pipe was placed in a horizontal position. One-half inch holes were drilled through the wall of each pipe in various places and a short section of three-fourths inch thin brass tube was soldered around each. Corks were placed in each small tube through which thermometers were inserted so the bulbs extended one inch inside the wall of the large tin pipes.

The coils were connected in series, as in previous cases, and a current of electricity was passed through and regulated so as to bring the temperature of the air within the large pipe to approximately 150° C. in a room whose temperature remained between 26° C. and 27.5° C. Exchanging heating coils or exchanging positions of the tubes made practically no difference in the temperature maintained by the given current. One of the pipes was then covered with one layer of commercial asbestos paper and after thorough drying the tests were repeated, using the same current, with results as shown in Table III.

TABLE III.—Temperature Records of Covered and Uncovered Vessels.

Temp. Room	Temp. Covered	Temp. Uncovered	Excess
27.5	121°	156°	35
*26.	118°	152°	34
26.	120°	152°	32
26.1	118°	152°	34
26.	118°	154°	36
†26.4	122°	155°	33

* Exchanged positions of vessels.
† Exchanged heating coils.

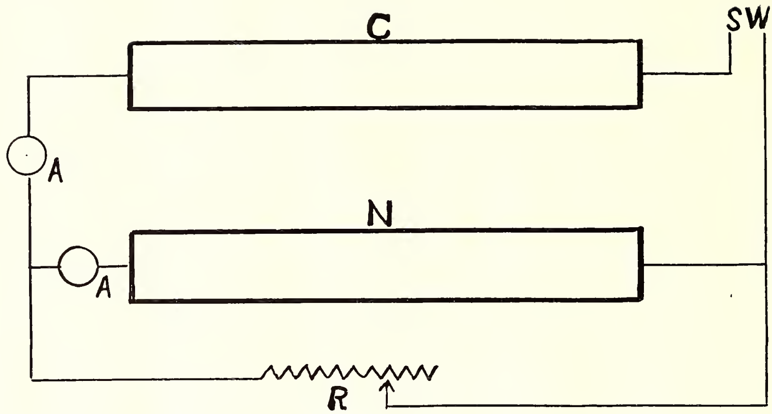

Fig. 2—Diagram of apparatus used in insulation tests.

An arrangement was made as shown in figure 2 which made it possible by trial to obtain a current in each coil of such a value that the naked pipe N and the covered pipe C were kept at the same temperature, 145° C. to 146° C. in a room whose temperature ranged from 27° C. to 28.5° C.

As the coils were no longer carrying the same current and consequently were themselves at quite different temperature, their difference in resistance had to be taken into consideration. The current and the potential drop in each coil was measured and from these data the energy developed per second in each pipe could be calculated.

The temperatures inside the pipes were maintained for at least one hour in each test and were determined by the average of the readings of five similar thermometers inserted at intervals along each pipe. When a steady state was reached the five thermometers in the same pipe did not differ among themselves more than 1.5° C. at any time.

A temperature of 140° (approximately 300° F.) was maintained in each pipe and the necessary current and potential drop in each coil noted, from which the heat energy developed in each was computed. These results appear in Table IV.

TABLE IV.—Temperature Records and Energy Required to Maintain a Temperature of 140° C.

Time	Temp.	Temp. (C)	Temp. (N)	Amperes		Volts	
	Room	Covered	Uncovered	C	N	C	N
7:30	27.5	144.	142.	10.3	8.2	62.	50.2
8:30	28.	141.	141.5	10.15	8.2	61.	50.2
9:00	28.	140.	141.	10.	8.25	60.	50.3
9:30	28.2	140.5	140.	10.1	8.2	60.2	50.3

Input in watts C=60.22; N=41.25.

Covered pipe requires nearly 45% more energy to maintain a temperature of 140° C. than does the naked one.

That a *thin* layer of some poor conducting material applied to a polished surface increases the rate of loss of heat from that surface is a well known fact. The increased radiation resulting from the profound change in the nature of the exposed surface frequently outweighs the insulating effect. The covering of many smooth, bright and even polished surfaces of vessels, and especially of hot-air furnace pipes, with a thin layer (usually a single thickness) of asbestos paper in response to the popular notion that it prevents the escape of heat, appears to be a mistaken procedure. Its use as a covering for hot-air pipes must be justified on some other grounds.

It has not been the purpose of this paper to quote exact quantitative results. Work is in progress now which will yield quantitative losses from various surfaces under conditions experienced in actual practice. This work will form the basis of another paper to be published soon.