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MOUND LABORATORY

Operated By

MONSANTO CHEMICAL COMPANY

MIAMISBURG, OHIO

M. M. Haring
Laboratory Director

CALORIMETRY PROGRESS REPORT

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CALORIMETRY

Group 8

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* Terminated March 4, 1949.

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ABSTRACT

I-A. The constant temperature bath is in operation. A ballistic type instability was detected in the calorimeter circuits and corrected by grounding the bath.

B. Calorimeters 37, 39, 40, and 43 have been installed and are now being run. Calorimeter 40 was found to be unstable. It is to be disassembled and examined for the trouble. Calorimeter 46 was finished and placed in operation December 20, 1948. Construction details are discussed. The thermel is of brass and the gradient medium is a paper tube. It is a single sided calorimeter of the form of Calorimeter 43. The thermel was made continuous to check the amount of interaction between the arms of the bridge.

C. Six Logac samples were run in Calorimeter 38. The sample numbers are 1114, 1110, 1105, 1104, 1103, and 1102. Tests of this calorimeter are in Table I. Comparison of Calorimeter 38 in a water bath and in an ice bath is shown in Table II. Good results were obtained for such drastic change in environment. Calorimeter 38 was turned over to Calorimetric Assay about March 15, 1949 marking the end of the tests of this particular microcalorimeter.

Calorimeter 44 was completed and installed in the ice bath on March 22, 1949. Table IV shows the results of tests. The zero bridge potential is small and is very stable compared to Calorimeter 38. The thermal form is of glass with the view of attaining a higher sensitivity than Calorimeter 38. A ten per cent increase was obtained. The problem of the low sensitivity compared to the theoretical value is to be examined. Two Logac Samples 1114 and 1102 were run. The comparison of the values with those from Calorimetric Assay is summarized in Table III. The characteristics of Calorimeter 44 are shown in Table V.

D. The calorimeters for Scioto Laboratories are in the process of being constructed. They are to be Calorimeter 39 type.

II. No progress was made on the rod calorimeter.

III. There was no progress on other types of calorimeters.

IV. There was no progress on the half-life evaluation.

V-A. The water bath and the proportional temperature control are discussed slightly. Pictures are included to give an idea of the setup.

B. Construction details are given for the platinum-manganin bridge-type thermometer. An instrument was needed that could be used to detect bath temperature changes of the order of 0.0005°C . The thermometer was installed.

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in the bath on March 29, 1949. With the bridge current at 10 milliamperes, the measured sensitivity is 2.5 microvolts per 0.001°C . change in temperature. The calculated time constant using natural logarithms is 0.067 sec.^{-1} . The time to get within 0.01 per cent of equilibrium after a thermal disturbance is 2.3 minutes.

VI-A. The theoretical dispersion and resolving power of the 60° sector mass spectrograph for masses of 200 were calculated.

B. The constant required for calibration of the magnetic field of the mass spectrograph was determined from experimental data. Using this constant, the flux density was found corresponding to a series of current input.

C. The temperature difference between the inner and outer walls of a quartz capillary containing polonium was calculated. The volume of polonium in the capillaries was recalculated and the density re-evaluated.

D. The mean count, mean diameter, and mean thickness of each of fifteen cleaned platinum discs were calculated for R. A. Staniforth.

DETAILED REPORT

I. Development of Micro and Macrocalorimeters of the Resistance Bridge Type

ORIGIN - Assay and Inventory Groups of Operations.

OBJECTIVE - Improvement of present Operation's calorimeters.

BACKGROUND - The calorimetric method has been the standard for Research and Operations assays.

STATUS -

A. General

The constant temperature baths used at Unit III have been deemed obsolete. Their condition was such as to make salvage unprofitable. The new bath has been in operation for the past few weeks. It shows promise of being a distinct improvement on the other baths. The capacity of this bath is not more than four calorimeters. Calorimeters 37, 39, and 43 are now operating.

During operation of these calorimeters and Calorimeter 44 in the ice bath, the high sensitivity galvanometer was found to exhibit an occasional and very disturbing instability. The instability was a ballistic type kick of several centimeters to the right or left followed at a random length of time later by a

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kick in the opposite direction. The cause of this was found to be the off-on heater in the bath controlled by the mercury regulator. The mechanism for the induction of current into the calorimeter circuits was found to be the bath not being grounded. The bath has been grounded and the instability removed. However, it is not understood how this effect was transmitted to Calorimeter 44 which was isolated from the water bath.

B. Macrocalorimeters

1. Calorimeters 37, 39, and 43

These calorimeters are being used for a routine series of runs of the laboratory standard.

2. Calorimeter 40

This calorimeter has been run in the new bath and was found to have a high resistance short in the bridge. It is to be torn down and the trouble located. The thermel had a special construction. Scotch Tape was used to insulate the coils of enameled nickel wire from each other and from the thermal form. Recent experience indicates that this tape ages rapidly and is probably quite hygroscopic, thus leading to instability.

3. Calorimeter 46 ✓

Calorimeter 46 was finished and put in the bath on December 20, 1948. It is an experimental calorimeter being fundamentally like Calorimeter 43 except for certain major changes. Calorimeter 43 indicated that this kind of construction is beneficial in several ways. First is improved steadiness, which apparently is caused by the closer thermal and mechanical association of the four arms of the bridge. It was thought that if the thermel were made of metal, brass in this case, that an even closer effective association could be obtained in Calorimeter 46 than was obtained with the plastic thermel in Calorimeter 43. Also, brass has a much lower coefficient of expansion which will help. (Stretching of wire was indicated in Calorimeter 43 by a noticeable change of zero after running large samples.) Secondly, a large gain in sensitivity was obtained in Calorimeter 43 which is inherent in this type of construction. A high sensitivity is useful in that it can be reduced in order to improve other characteristics, such as speed and stability. In Calorimeter 46 stability may be improved by the lower bridge resistance and size wire (No. 36 99 Alloy). Speed may be improved by using a gradient medium other than air (in this case, paper). Also a paper gradient medium makes ease in construction as well as reducing the end effects, since now the medium around the ends is air. It is possible to reverse a bad situation in this way. Before, we had a high conductivity where we did not want heat to flow and a low conductivity where we wanted heat to flow.

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In one run of Calorimeter 43 a heat distribution error of 0.3 per cent was found. Since the only known deviation in symmetry was caused by the leads, the leads were attributed to causing this heat distribution error. Construction difficulties in Calorimeter 43 required straight vertical leads from the socket. This meant a lead length of only three inches. To get around using short leads in Calorimeter 46, the leads were brought out above the heater through the thermel and down the outside of the thermel to the socket. This should reduce the heat distribution error.

Against better judgement and only for sake of further knowledge of this type of construction, the brass thermel was made continuous along the entire length. It was thought that too much interaction of heat flow might cause errors because of imperfect cancellation of changes in the distribution of heat. If results show inaccuracies which can be attributed to this source, then the calorimeter will be disassembled and the brass thermel will be broken into three sections with air gaps between elements.

Test results on this calorimeter will be given in a future progress report.

C. Microcalorimeters

1. Calorimeter 38

This calorimeter was turned over to Calorimetric Assay about March 15, 1949. The test data shown in Table I were taken with the calorimeter in an ice bath in Laboratory R-109. It is to be noted that Calorimetric Assay has it installed in a constant temperature water bath operating near room temperature.

Six Logac samples were run during February and March, 1949. Samples 1110, 1103, 1104, and 1105 were reported February 25, 1949 in Memorandum Number 49-2-54 in which Calorimeter 38 is compared with the Macrocalorimeter Number 30. Samples 1114 and 1102 were reported March 10, 1949 in Memorandum Number 49-3-12.

Table II compares Calorimeter 38 when run in an ice bath and a water bath. Comparing these results with the per cent differences shown in Table III, it is seen that Calorimeter 44 gives values considerably in excess of Calorimeter 38. However, some of the difference indicated in Sample 1114 must contain errors due to the size of the sample. It is interesting to note that the characteristics of Calorimeter 38 did not change in the shift from an ice bath to a water bath.

This report closes research Calorimeter 38.

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Table I

TESTS OF CALORIMETER 38

Date	Zero Bridge Potential μV .	Slope	Heater Current ma .	Bath Temperature $^{\circ}\text{C}$.	Sensitivity $\text{mc./}\mu\text{V}$.	Sample Value Curies	Time	Remarks
2-4	+8797.8	-16.97	15.002	1.389	0.077515			Var. Zero Bridge Pot. 1.7 μV .
2-7	8651.1	-18.13	15.002	1.393				Var. Zero Bridge Pot. 1.6
2-8	8563.3		8.594	1.390				Var. Zero Bridge Pot. 2.1
2-9	8483.9	-23.25	14.997	1.393				Var. Zero Bridge Pot. 0.4
2-14	8127.2	-23.57	14.997	1.389				Var. Zero Bridge Pot. 0.6
2-15	8193.7		8.745	1.389		0.21402	2:00	Sample No. 1110-Microassay Group
2-16	8201.1		9.214	1.391		0.235911	12:00	Sample No. 1103-Microassay Group
2-17	8223.1		8.970	1.389		0.223305	11:00	Sample No. 1104-Microassay Group
2-18	8239.8		8.539	1.389		0.201989	1:00	Sample No. 1105-Microassay Group
2-21	Stirrer Broke - Repaired							
2-22	8187.8	-36.41	14.999	1.389				Var. Zero Bridge Pot. 2.7 μV .
3-1	7964.5	-24.59	14.984	1.389				Var. Zero Bridge Pot. 4.2
3-2	7942.2	-24.90	14.984	1.391				Var. Zero Bridge Pot. 0.9
3-3	7960.8		8.006	1.390		0.181209	12:00	Sample No. 1102-Microassay Group
3-4	8019.4		4.993	1.392		0.077290	12:00	Sample No. 1114-Microassay Group

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** Calorimeter 38 in ice bath.

* Calorimeter 38 in water bath.

Per Cent Difference (Assay - Research)

+0.06

** Research Calorimetry, 1 Run

0.05723

* Calorimetric Assay Mean of 3 Values

0.05757 curies

Sample 1114

Per Cent Difference (Assay - Research)

+0.02

** Research Calorimetry, 1 Run

0.133502

* Calorimetric Assay Mean of 3 Values

0.133760 curies

Sample 1102

VALUES DECAYED TO MAY 3, 1949

Table II

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COMPARISON OF CALORIMETRIC ASSAY AND RESEARCH CALORIMETRY

LOGAC SAMPLES 1102 AND 1114 - MICROASSAY GROUP

CALORIMETERS 38 AND 44

Calorimetric Assay					Research Calorimetry				
(A)					(B)				
No.	Sample	Date	Value Curies	Decayed to 5/3, 12:00	Date	Time	Value Curies	Decayed to 5/3, 12:00	Remarks
1	1102	3/22	0.165204	0.133862	4/8	12:00	0.152009	0.134118	Val. Calc. using Zero after Run
2		3/24	0.163309	0.133659	4/20	2:00	0.143750	0.134744	Val. Calc. using Zero before Run
3		3/30	0.158592	0.133759	4/20	2:00	0.143550	0.134557	Val. Calc. using Zero after Run
4		Mean Value		0.133760					
5	1114	3/23	0.07067	0.05755	4/15	12:00	0.062092	0.056739	Val. and Slope Calc. from Zero Before
6		3/25	0.06987	0.05747	4/15	12:00	0.06362	0.05832	Val. Using Zero after-Slope Using Zero
7		3/31	0.06806	0.05769	4/15	12:00	0.064241	0.058703	Before
8					4/15	12:00	0.063822	0.058320	Val. Using Zero Before-Slope Using
9		Mean Value		0.05757					Zero after
10					1102				Val. and Slope Using Zero after
11									
12									
13					1114				
14									
15									
16									

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2. Calorimeter 44

This calorimeter was finished and installed in the ice bath on March 22, 1949. Figures 1 and 2 show the ice bath and Calorimeter 44. The construction details of Calorimeter 44 are to be found in Calorimetry Progress Report, MLM-234, November 1-30, 1948, and those of the ice bath are in the Calorimetry Progress Report, MLM-192, September 1-30, 1948.

Table IV shows test data on Calorimeter 44 to the present time. The smallness of the zero-bridge potential compared to Calorimeter 38 is due to the closeness of balance in the bridge coils when the calorimeter was assembled. That this is fortuitous is realized since the bridge wire had a resistance of 96 ohms per inch.

Again compared to Calorimeter 38, this calorimeter has a stable zero. Since construction, the zero of Calorimeter 38 has increased steadily from about 2400 microvolts to about 8000 whereas the zero of Calorimeter 44 has varied only between 487 and 610 microvolts. The zero is not as steady as could be desired; it varies by approximately six microvolts in six hours of continuous observation. Five microvolts change in zero will introduce an error of 0.2 per cent in a sample of 200 millicuries. The error is inversely proportional to the sample size so that a five microvolt change would introduce a 1.0 per cent error in the determination of a sample of 40 millicuries.

The slope of Calorimeter 44 may change considerably without introducing too much error. It may change by 3.1 to give an error of 0.1 per cent. This is shown in Table III where item 6(B) was calculated with a slope equal to 27.76 and 8(B) with a slope of 23.56. The difference is negligible. The effect of change of zero of four microvolts is also shown. The result is a 0.6 per cent difference between items 7(B) and 8(B).

Table IV indicates that in general the zero-bridge potential increases after a run though not as much as did Calorimeter 38. By comparing Calorimeter 38 with 39, the laboratory standard calorimeter, it was found that the zero after the run was the more reliable. Calorimetric Assay has also found this to be the case. Calorimeter 44 behaves in the same manner; Table III shows that the values calculated using the zero after the run are closer to Calorimeter 38 values. Calorimeter 44 is to be compared with Calorimeter 39 in the very near future.

The cooling curve of the heater side of Calorimeter 44 was run with the following results. The time constant, λ , using common logarithms is 0.00079 sec.⁻¹ which means that it takes one hour and 50 minutes for the calorimeter to come within 0.01 per cent of equilibrium.

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LEGEND FOR FIGURE 1

ICE BATH

- A - Beckman Thermometer.
- B - Stirrer Motor.
- C - Styrofoam Lid of the Ice Bath.

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Figure 1

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Ice Bath

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LEGEND FOR FIGURE 2
ICE BATH AND CALORIMETER 44

- A - Four Inches of Styrofoam Insulation All Around the Bath.
- B - Calorimeter Leads.
- C - Heater Side of Calorimeter.
- D - Sample Side of Calorimeter.
- E - Removable Plug of Polystyrene so that Condition of Drierite May Be Observed.
- F - Window of Polystyrene for Same Purpose As in E.
- G - Mixture of Distilled Water and Distilled Water Ice.

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Figure 2

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Ice Bath and Calorimeter 44

SECRET**UNCLASSIFIED** Table IVTESTS OF CALORIMETER 44

Date	Zero Bridge Potential $\mu v.$	Slope	Heater Current ma.	Bath Temp. $^{\circ}C.$	Sensitivity mc./ $\mu v.$	Heater Resistance Ohms	Sample Value Curies	Time	Remarks
3-22	532.0			---					Zero Study-Var. Zero Brdg. Pot. 50 $\mu v.$
3-23	Stirrer Motor Changed								
3-24	487.8			0.907					Var. Zero Brdg. Pot. 2.5 $\mu v.$ -3 hrs.
3-25	500.6			0.901					Var. Zero Brdg. Pot. 5.5 $\mu v.$ -6 hrs.
3-29	574.3			0.899					Var. Zero Brdg. Pot. 2.7 $\mu v.$ -2 hrs.
3-30	574.4			0.900					Var. Zero Brdg. Pot. 0.3 $\mu v.$ -1 hr.
3-30	572.8			0.901					Zero Taken Before Renewal of Ice
*3-31	Cooling Curve was Run $\lambda_{10} = 0.00079 \text{ sec.}^{-1}$, $T(0.01\%) = 1 \text{ hr. } 50 \text{ min.}$								
4-4	597.5			0.892					Zero Drifted Slowly 600.0 to 595.5
4-6	608.4			0.892					Var. Zero Brdg. Pot. 0.5 $\mu v.$ -9 min.
4-7	609.1	23.04		0.897					Slope Calc. from Zero Before Run
4-7	608.0	23.39		0.896					Slope Calc. from Zero after Run
4-8	608.3			0.897			.152009	12:00	Spl. 1102 - Microassay Group
4-12	602.3		17.886	4.960	0.07129	70.7553			Sens. Calc. from Zero Before
4-13	609.0			4.955					Bath Temp. Var. 4.955 to 4.959
4-13	610.7	24.93	17.564	4.955					Slope Calc. from Zero After Run
4-14	600.0	27.76	11.451	4.959					Slope Calc. from Zero After Run
4-14	606.4	23.56	11.451	4.959					Slope Calc. from Zero Before Run
4-15	606.9	27.76	5.3431	4.960			.062092	12:00	Sample Val. Calc. Using Slope and Zero Listed
4-15	610.9	27.76	5.3431	4.960			.06382	12:00	Sample 1114 - Microassay Group
4-15	606.9	23.56	5.3431	4.960			.064241	12:00	
4-15	610.9	23.56	5.3431	4.960			.063822	12:00	
4-19	591.1	29.94	18.620	4.980					Slope Calc. from Zero After Run
4-20	606.5	29.94	8.036	4.969			.143750	2:00	Sample 1102 - Microassay Group
4-20	609.3	29.94	8.036	4.969			.143550	2:00	Spl. Val. Calc. from Zero After Run
*3-31	584.4		9.9953	0.901	0.07109	70.7460			

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The sensitivity of the heater side has been measured and is 14.07 microvolts per millicurie. This is a ten per cent increase over Calorimeter 38. In using a glass thermal form in Calorimeter 44 as compared with an aluminum form in Calorimeter 38, it was thought that the sensitivity would be considerably increased due to reduction of heat leaks from the ends of the thermel. Since the expected increase was not realized, it means that at least three things are left for further consideration.

1. The heater and thermal leads may be the source of the heat leaks. From previous experiments and considerations, it seems unlikely that five-sixths of the heat of the heater or sample is leaving the calorimeter by this route.

2. The No. 14 Alloy wire used in the thermel may not have, at the operating temperature, the value of the temperature coefficient of resistance listed in the manufacturer's catalog.

3. The sensitivity equation may have an incorrect theoretical basis. These points are to be given further consideration. The properties of Calorimeter 44 are summarized in Table V.

Table V

CHARACTERISTICS OF CALORIMETER 44

Sensitivity of heater side	14.07 $\mu\text{v. mc.}^{-1}$
Resistance of heater	70.746 ohms
Time constant (λ_{10})	0.00079 sec.^{-1}
Time to 0.01 per cent equilibrium	1 hr. 50 min.
Change of slope (ΔM) for 0.1 per cent error in sample	3.11
For a sample of 40 mc. a 5 v. uncertainty in BP ₀ or BP will give an error	1.0 per cent

D. Calorimeters for Scioto Laboratory

The 39 type calorimeter has been decided on as the type to be supplied. Raw material has been received and is now being processed. Tentatively, the quantity has been set at six.

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II. Study and Design of a Rod Type Calorimeter

STATUS - No progress.

III. Critical Study and Evaluation of Other Type Calorimeters

STATUS - No progress.

IV. Half-Life of Polonium

STATUS - No progress.

V. Materials of Research

A. Constant Temperature Water Bath and Control Equipment

The new bath has been completed and is in operation. Figure 3 shows a top view. In the far right hand corner of the bath is the bridge that actuates the proportional heater control shown in Figure 5. The upper panel is the proportional control and the lower panel contains a device for protecting the high sensitivity galvanometer and for shifting control from the electronic device to the mercury regulator shown near the bridge in Figure 3. The high sensitivity galvanometer is a part of an optical system that is not shown in this group of photographs.

Figure 4 shows the calorimeter control panels, the photo-bridge and bridge thermometer control panel, galvanometer and telescope system, and the Wenner potentiometer.

More detailed reports are planned for these items.

B. Manganin-Platinum Bridge Thermometer

ORIGIN AND OBJECTIVE - J. F. Eichelberger suggested the possibility of constructing a thermometer based on the bridge principle so that the calorimeter operator may read the bath temperature at the potentiometer. This eliminates the necessity of going to the bath to read the Beckman thermometer. It was also recognized that a bridge-type thermometer could be made to be more sensitive than a Beckman and to have a faster response to bath temperature changes. With these things in mind a bridge-type thermometer was constructed.

BACKGROUND - The design followed the following calculations:

(a). Platinum was decided on for two arms of the bridge with idea that it may be the most stable material we might have on hand. For this reason,

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LEGEND FOR FIGURE 3

THERMOREGULATED WATER BATH

- A - Mercury Regulator.
- B - Bridge for Heater Photocontrol.
- C - Control Heater.
- D - Calorimeters.
- E - Steady Heater.
- F - Booster Heater.
- G - Stirrer and Motor.
- H - Beckman Thermometer.
- I - Leads for Platinum-Manganin Bridge Thermometer.
- J - Copper Tube Soldered to the Bath to Maintain Bath Water at a Constant Level.
- K - Five-Gallon Water Supply for Bath.

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Figure 3

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Thermoregulated Water Bath

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LEGEND FOR FIGURE 4

PROPORTIONAL CONTROL FOR WATER BATH

- A - Proportional Heater Control Unit.
- B -- Protective Device for Galvanometer and also for Manual or Automatic Switching of the Bath from Proportional Photocontrol to On-Off Mercury-Regulator Control.

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Figure 4

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Proportional Control For Water Bath

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LEGEND FOR FIGURE 5

CALORIMETER CONTROL EQUIPMENT

- A - Calorimeter Control Panel. Four Panels are Shown in this Console.
- B - Current Control for Bridge Thermometer.
- C - Current Control for Bridge of the Proportional Photocontrol Heater.
- D - Plywood Shroud for High Sensitivity Galvanometer.
- E - Galvanometer Telescope and Stand.
- F - Wenner Standardizing Potentiometer.

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Figure 5

Calorimeter Control Equipment

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nickel was ignored even though it has approximately twice the temperature coefficient of resistance of platinum.

(b). The resistance of each arm of the bridge was chosen to be approximately 100 ohms.

The voltage change in the bridge due to 0.001°C . change of the temperature of the bath is roughly calculated as follows for a ten milliampere bridge current.

$$\begin{aligned} E &= 0.005 \times 100 \times 0.0039 \times 0.001 \\ &= 2 \times 10^{-6} \text{ volts} = 2 \mu\text{v}. \end{aligned}$$

Equation for calculation:

$$E = IR\rho\Delta t$$

where:

- I = Half the bridge current = 0.005 amperes,
- R = Resistance of one arm of bridge = 100 ohms,
- ρ = Temperature coefficient of resistance (platinum),
= 0.0039 ohms ohms⁻¹ $^{\circ}\text{C}.$ ⁻¹,
- Δt = Assumed temperature change of bath = 0.001°C .

To realize the full sensitivity of the bridge, it should be connected as follows:

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This appeared to be sensitive enough for a trial thermometer. Two microvolts per 0.001°C . bath temperature change would allow for the detection of a change of the order of 0.0005°C . The Beckman can not be used on such a change. By boosting the bridge current the thermometer can be made more sensitive. For instance, by using a bridge current of 40 milliamperes, a bath temperature change of 0.0002°C . would unbalance the bridge by $1.6\mu\text{v}$.

As a consequence, if the thermometer shows inherent stability, it will be an asset for checking the ability of the photorelay proportional heater control to maintain the temperature of the bath.

STATUS - The thermometer was constructed as shown in Figures 6 and 7. The sizes of the glass tubes were a compromise between ruggedness and the desire to get minimum time of response. The outside diameter of the inner glass, upon which the bridge coils are wound, was chosen to reduce any air space between the coils and the outer glass jacket to a minimum depending on the stock sizes of glass tubing. The Glass Shop made the outer jackets and cut the inner tubes to the desired length.

Other designs for this unit were considered. The idea of winding all four coils on the same form to eliminate one of the tubes (as shown) was seriously considered; but was rejected, because it meant bringing lead wires from the lower coils over the upper coils thus requiring the inside diameter of the outer jacket to be of such size as to leave a relatively large air gap between the coils and the outer jacket and thus, increasing the time of response of the thermometer. The design chosen is that shown in Figure 6.

The control panel was incorporated into the control panel for the bridge of the photorelay. It consists of a Leeds and Northrup decade-resistance box, a one ohm NBS-type standard resistor, an 0-150 milliammeter, and a double-pole, double-throw switch. These were connected as in this sketch.

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Figure 6

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Platinum-Manganin Bridge Thermometer

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Figure 7

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Close-up View of Ends of Bridge Thermometer

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The thermometer was installed March 29, 1949. The zero-bridge potential at the approximate bath temperature of 24.5°C . is $-3681 \mu\text{v}$. During a two-hour test run of the thermometer with a 10 ma. bridge current, the bridge potential showed a change of $4 \mu\text{v}$. with a change of 0.002°C . on the Beckman. A sensitivity check was made on March 30, 1949. The temperature of the bath was changed by 0.013°C . by adjusting the mercury control. This change produced a change in the bridge thermometer potential of $33 \mu\text{v}$. The sensitivity is then:

$$\text{Sensitivity} = \frac{33}{13} = 2.5 \mu\text{v./}0.001^{\circ}\text{C}.$$

This agrees well with the approximate calculation. It is planned to continue reading the Bridge Thermometer and the Beckman together for several weeks to uncover any instability that may show up. To the present, it has not been in operation long enough to present any further data.

VI. The time constant was calculated from the following data shown in Table

Table VI

DIMENSIONS AND MATERIALS OF THE BRIDGE THERMOMETER

<u>Material</u>	<u>Radius cm.</u>	<u>Density g. cm.⁻³</u>	<u>Specific Heat cal.-g.⁻¹-^oC.⁻¹</u>	<u>Thermal Conductivity cal.-cm.⁻¹-sec.⁻¹-^oC.⁻¹</u>
Glass	$r_0 = 0.391$	$d_1 = 3.5$	$S_1 = 0.18$	$k_1 = 0.002$
Platinum Wire	$r_1 = 0.287$	$d_2 = 1.50$	$S_2 = 0.10$	$k_2 = 0.00017$
Glass	$r_2 = 0.239$	$d_3 = 3.5$	$S_3 = 0.18$	
Air	$r_3 = 0.152$	$d_4 = 0.0012$	$S_4 = 0.24$	
	$r_4 = 0.00$			

$$\lambda(\text{natural logarithm}) = 0.067 \text{ sec.}^{-1}.$$

Time to get to 0.01 per cent of equilibrium

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VI. Applied Mathematics in Research and Production

ORIGIN - Needs of the Physics Section.

OBJECTIVE - To conduct mathematical investigations for the various Research and Production Groups.

BACKGROUND - This project was set up to expedite the numerical sections of reports and to aid in the preparation of tables and figures to appear in reports.

STATUS -

a. The formulas for dispersion and resolving power of a mass spectograph as given by Shaw and Fall¹ were verified. The 60° sector instrument being tested has a slit width of 0.008 inch and a radius of curvature of 12.5 cm. Theoretical values of the dispersion and resolving power of this machine corresponding to a mass of 200 were computed.

b. The flux density, B, of a magnetic field may be determined using the formula

$$B = \frac{DR}{kNA} \times 10^8,$$

if k is known. k is a constant for the galvanometer used to measure the deflection, D, obtained when a test coil of N turns is drawn through the magnetic field. R is the resistance of the system in ohms and A is the area of the test coil in square centimeters.

A preliminary experiment was conducted to determine k. The deflection, D, of the galvanometer was measured for a series of observations using a fixed voltage, v, and a varied capacitance, c. For each observation, $k = D/cv$ was calculated and the average, $k = 428 \times 10^6$, was obtained.

In the final step, a test coil of three turns, a diameter of 2.025 cm. and a resistance of 24,000 ohms were used. The current input was varied and the corresponding galvanometer deflection, D, was observed at each step. B was calculated for each deflection measured, and a graph was plotted showing B in gauss against current in milliamperes.

c. The formula for the conduction of heat through a homogeneous cylindrical wall

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$$\frac{q}{L} = \frac{2\pi k \Delta t}{\ln r_2/r_1}$$

was used to find the temperature difference, Δt , between the inner and outer walls of a quartz capillary containing polonium. An average value of about 5°C . was found. It had been assumed in previous density calculations that this difference was about 50°C .² Hence, a re-evaluation of the density was necessary.

Since the original calibration curves for the three capillaries involved were no longer available, the volume of polonium in the capillaries had to be recalculated. Interpolation formulas using sets of three points from the original data were used to evaluate the volume of polonium present.

The density was recalculated for the last three determinations reported in the Information Meeting Paper No. 13, Density of Metallic Polonium, by B. Ercdy, MLM-230, November 9, 1948.

d. Platinum discs which had been cleaned were counted for residual polonium. Each disc was counted on several machines on both sides. The diameter and thickness of each disc were measured ten times.

Values which deviated from the average so much that their effect would be disproportionate were discarded from each set of observations by use of Chauvenet's criterion.

After using Chauvenet's criterion, the mean count, mean diameter, and mean thickness of each disc were computed. The probable error of the mean was found for each case.

FUTURE PLANS

a. Design a super microcalorimeter as put forward in the Calorimetry Progress Report, MLM-234, November 1-30, 1948.

b. Study theoretically the response of a mass of metal specially insulated to room temperature variations and the possibilities of using such a mass as the constant temperature environment for the super microcalorimeter and for the rod-type calorimeter for small and medium samples.

c. Design and build a true guard ring calorimeter.

d. Design a combination bath that can be used as either an ice bath or a water bath for the macrocalorimeters.

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e. Calorimeter 24 is to be reinstalled in the bath after it has been brought under control using the photobridge-proportional heater control. The sample on which the original half-life data were taken is to be checked now that several half-lives have elapsed.

REFERENCES

1. Shaw, A. E. and Rall, W., "An A.C. Operated Mass Spectograph of the Mattauch Type," Review of Scientific Instruments, 18, pp. 279-280 (1947).

2. Brody, B. B., "Density of Metallic Polonium," Information Meeting Paper No. 13, MIM-230, November 9, 1948, Mound Laboratory, Monsanto Chemical Company, Miamisburg, Ohio.

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