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Actino- And Thermo- Response Of Molybdenite In Vacuo With Various Colored Lights

John H. Fulton
Fort Hays Kansas State College

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ACTINO- AND THERMO- RESPONSE OF MOLYBDENITE IN VACUO WITH VARIOUS COLORED LIGHTS

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By

John H. Fulton, B. S.

F. H. K. S. C.

Approved by

Harvey A. Zinszer

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INTRODUCTION

The actino-sensitivity of mineral substances has been studied by a number of investigators, among whom Hankel[1] is the pioneer. Actino-sensitivity or actino-electricity is the emf generated in a crystal when exposed to light or radiant heat, as indicated by a sensitive galvanometer.

In 1922, S. Kolzareff[2] discovered the actino-electric effect in molybdenite and about the same time Paul H. Geiger[3] discovered the same effect in argentite. Since Kolzareff's discovery, W. W. Coblentz[4] of the Bureau of Standards has done a vast amount of work in this special field (actino-electricity) particularly with the mineral molybdenite, and he also continued the investigation[5] of the thermo-electric effect of molybdenite instituted by Koenigsberger and Weiss[6] in 1911. As late as 1930, however, Otis Johnson[7] studied the actino-electric effect on molybdenite at higher temperatures, but in no instance was the effect of various colored lights studied under the influence of heat and in vacuo. Hence the present investigation was undertaken.

It might be well, at this point, to define more or less differentially the various co-effects associated with the one which embraces the main study in this thesis, namely, the actino-effect. They are: the thermo-electric or Seebeck effect; the actino-electric or Hankel effect; the photo-resistant or Smith effect; the photo-electric or Hallwachs effect and the thermo-resistant effect. These various effects together with others are discussed and defined in a chronological order in a paper entitled "Note on photoelectric phenomena," by Professor Zinszer[8]. It will be my pleasure to quote from his manuscript. "The thermo-electric effect applies to the emf produced in a circuit consisting of two different metals when a difference of temperature is maintained between their junctions. As stated before, the actino-electric effect is the emf generated in a crystal when exposed to light or radiant heat, no external emf being included in the circuit. The photo-resistant effect is the change in resistance of a cell when subjected to light or radiant heat, the cell being connected to an external emf. The photo-electric effect denotes the change in electrification of a body due to the liberation of electrons when electromagnetic radiation falls upon it. The thermo-resistant effect is merely the change in resistance experienced by a body when subjected to changes of temperature, this change being represented mathematically by the expression:

$$R_t - R_o = 1 + at + bt + ct \quad ....$$

Where R_o is the body's resistance at the temperature of melting ice; t is the temperature in degrees Centigrade and a, b, c, etc. are constants."

Thus in this thesis the term, actino-electricity, will be applied to the reactions resulting when the cell is subjected to light alone, no external emf being in the circuit. The term, thermo-electricity, will denote the production of an emf in the circuit due to the difference in temperature of the junctions between the various elements of the cell. The photo-resistant effect will designate the change in resistance of the cell when subjected to light or radiant heat, the cell being connected with an external emf. While the thermo-resistant effect will denote the ordinary change in resistance of the cell due to a change in temperature. The production of electricity by radiant heat which comprised the latter part of the investigation is merely a phase of the actino-electric effect.

Stated more explicitly, the purposes of this investigation are to study the reaction of molybdenite cells to light of various colors while in vacuo and at various temperatures. The samples of molybdenite were also subjected to radiant heat in the last part of the experiment, which was undertaken to determine to some extent the amount of thermo-electric effect which was due to thermal radiation in the first part of the investigation.

APPARATUS AND PROCEDURE

The cells consisted of the stem from the inside of an electric lamp bulb with the sample of molybdenite mounted on a small piece of asbestos paper clamped in the lead wires of the bulb. This assembly was fused into a test tube and a window of cortex glass sealed over the mouth of the test tube. When ready for evacuation, a small glass tube was fused on to the exhaustion tube of the electric lamp bulb, which in turn was sealed off after evacuation. The cell was then ready for the electric oven. Fig. 1 shows construction of the cells.

The cortex window is a special heat resisting glass with a constant transmission factor at and above 3100Å, while at 2800Å as much as 30% of the energy is transmitted. For the radiant heat experiments, the window was replaced by the heater element to be described in the discussion on the effect of thermal radiations. Fig. 2 shows the transmission relations for the cortex windows.

The oven was made by wrapping nichrome resistance wire around a small tin box, insulating the wire with asbestos cement. This assembly was placed in a larger tin box and the vacant space filled with dry asbestos cement. The leads were insulated with small glass tubes. The light source was a Cooper-Hewitt quartz mercury arc arranged for operation on 110 volts A.C. The color of the light was controlled by three filter arrangements in addition to the unfiltered arc. One filter was yellow in color and transmitted the 5461Å green line in addition

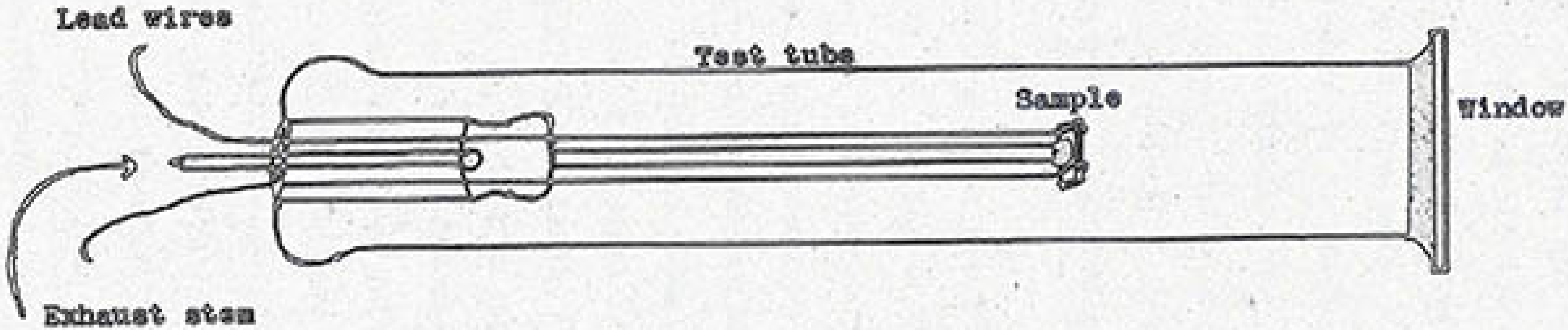


Fig. 1 Cell Construction

to all the longer wavelengths in the mercury spectrum. The other filter was blue in color and transmitted the 5461Å green line in addition to all the shorter wavelengths down to about 3200Å. The combination of both filters transmitted the 5461Å green line only. The unfiltered arc contains strong lines down to 2536Å, but as the transmission of the cortex window drops rapidly below 2800Å these lines are not considered as having much effect. A spectrum plate is shown herewith setting forth the various conditions described above. See Fig. 3a.

The work was started using a previous layout which was set up for the study of samples of molybdenite at high temperatures while at atmospheric pressure. An attempt was made to use a monochromatic illuminator to furnish light to project on the cells. It was found that no reaction could be secured with the monochromatic illuminator, due to the high internal resistance of all the sensitive galvanometers available. Accordingly, the project was changed to include a study of cells made so they could be evacuated, and used with a limited number of colored lights secured by filters. Several methods of making an airtight cell were tried, but due to the difficulty of annealing thick glass joints, all the early attempts were unsuccessful. The form of cell construction finally adopted is that shown in Fig. 1 above. The wires are already sealed through glass and annealed in the manufacture of the electric lamp bulb, and the portion of the lamp bulb which is to be

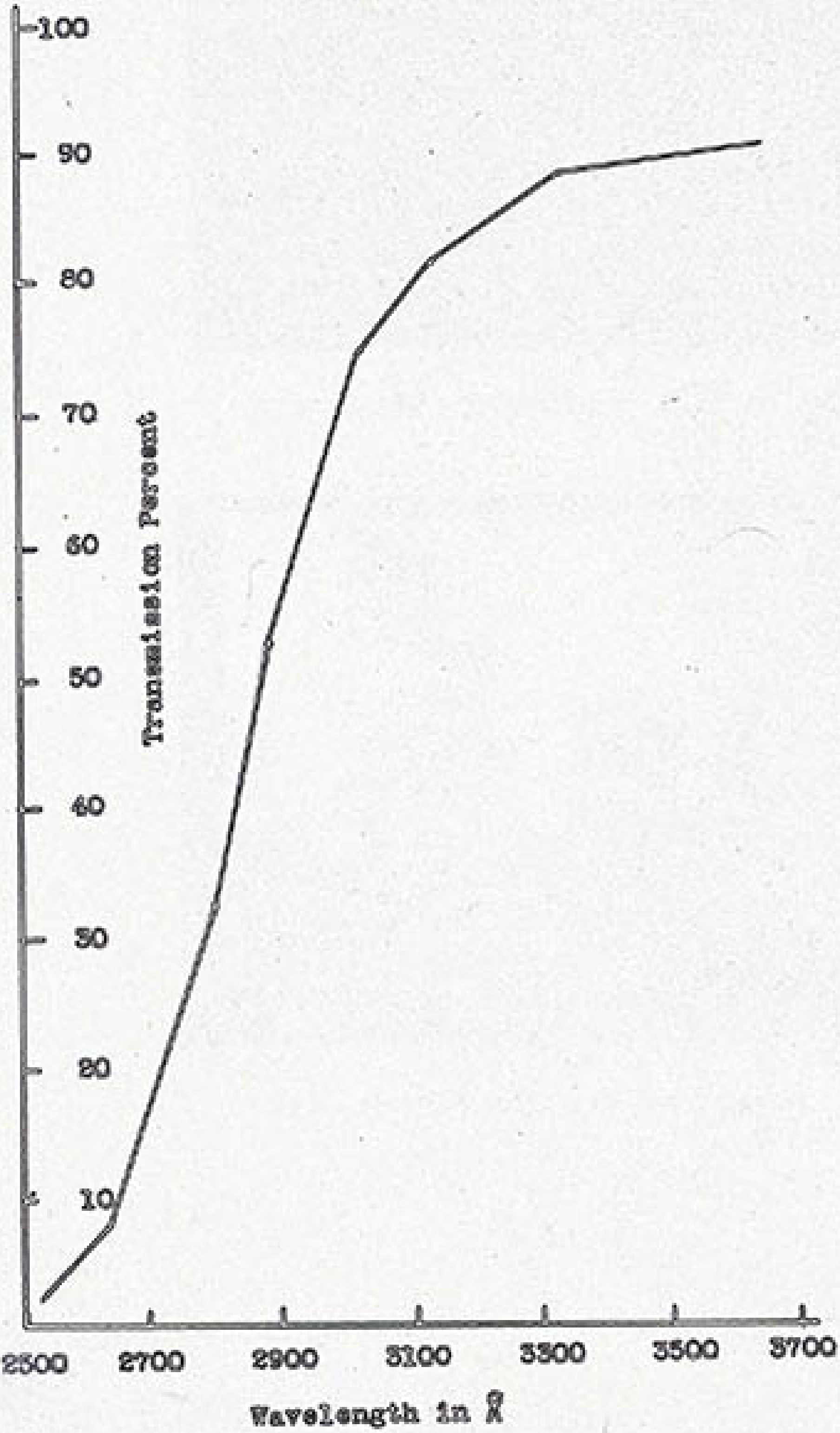


Fig. 2 Transmission of Cortex Window

Fig. 3a Transmission of Filters

Fig. 3b Photograph of Apparatus

fused to the test tube is blown out thin so that annealing is unnecessary. After the first lot of cells was constructed, they were tested for all the properties given in the paragraph on definitions. Several tests were run on each cell, including quite a few repetitions of the same tests. During these preliminary tests it was found that the temperature could not be safely raised above 100° C. if the actino-electric characteristics were to be preserved in their original form. It was found that the first lot of cells were not photo-resistant, or thermo-resistant enough to take into account in later experiments.

A new group of four cells was constructed and as a result of the preliminary findings, observations were taken in the following manner; the galvanometer was adjusted to zero while the cell was at room temperature. Light was then projected on the cell and the deflection noted. Readings were taken first for green light with both filters in place, then with the yellow filter in place, then the blue, followed by the unfiltered arc. The heat was then turned on and the temperature of the oven allowed to rise to slightly above 100° C. The current was then shut off and when the temperature had fallen to 100° C. a reading was taken for the effect of heat alone. Green light was then projected on the cell, and the deflection noted. The heat deflection was subtracted from this reading. This process was repeated with the yellow, blue, and unfiltered arc. The oven was then allowed to cool to 90° whereupon the entire process was repeated. Readings were taken every ten degrees down to 50° C. Each test was run twice for verification. The cell was then evacuated and two similar tests were run in the above manner. This process was applied to all four cells.

The window was then melted from a group of cells and a heating element put in its place. The first heating element consisted of about ten centimeters of #32 iron wire wound around a piece of chalk, the chalk being removed after the winding was done. Two lead wires were pushed through a rubber stopper and fastened to the heater element. A glass tube was also inserted through the rubber stopper for purpose of evacuation, and all joints were made air-tight with sealing wax. After preliminary tests with this heater, it was thought wise to wind the heater in the form of a flat spiral in order to present a more uniform radiating surface to the cell, and to provide some basis for calculating the actual amount of heat in calories per second that was being radiated in the direction of the cell. The resistance of the heater was 1.45 ohms, measured by impressing an accurately known voltage across it and reading the current with an accurate ammeter. This method of measurement was chosen because when the cell was in use, the current through it was the only quantity measured. Thus in order to determine the power used in the heater, the RI drop is used in place of the actual voltage across the system. The power used in the system is therefore given by 1.45 times the square of the current in amperes. In order to be exact in the calculation when the wire is at high temperature, it is necessary to apply the correction factor given by:

$$\alpha = \frac{R_t - R_o}{R_o t}$$

α is found to equal .005 ohms per ohm degree. It is easily seen that small temperature differences will not be important in the calculations, but as the wire was run from room temperature to a point about 200° below red heat, a difference in resistance amounting to 3.8 ohms occurs in the wire between its low temperature and its high temperature. It was found that the wire radiated a total of .014 calories per second with .2 amperes flowing through it and 2.85 calories per second with 1.5 amperes flowing through it. Of course only half of this amount was radiated in the direction of the cell.

Observations were taken by setting the galvanometer to zero while no current was flowing through the heater. The rheostat was then advanced to the point where the ammeter showed a flow of .2 ampere. The current was allowed to flow at this rate until the cell reached equilibrium or it was evident that no deflection was going to result. The rheostat was then advanced until the ammeter showed a current of .3 ampere. A reading was then taken when the cell had reached equilibrium. This process was repeated in .1 ampere steps up to 1.5 amperes. At 1.5 amperes the wire was just below red heat. The cell was then evacuated and readings taken again. Fig. 4 shows the layout of the apparatus and a diagram of connections, while Fig. 3b is a photograph

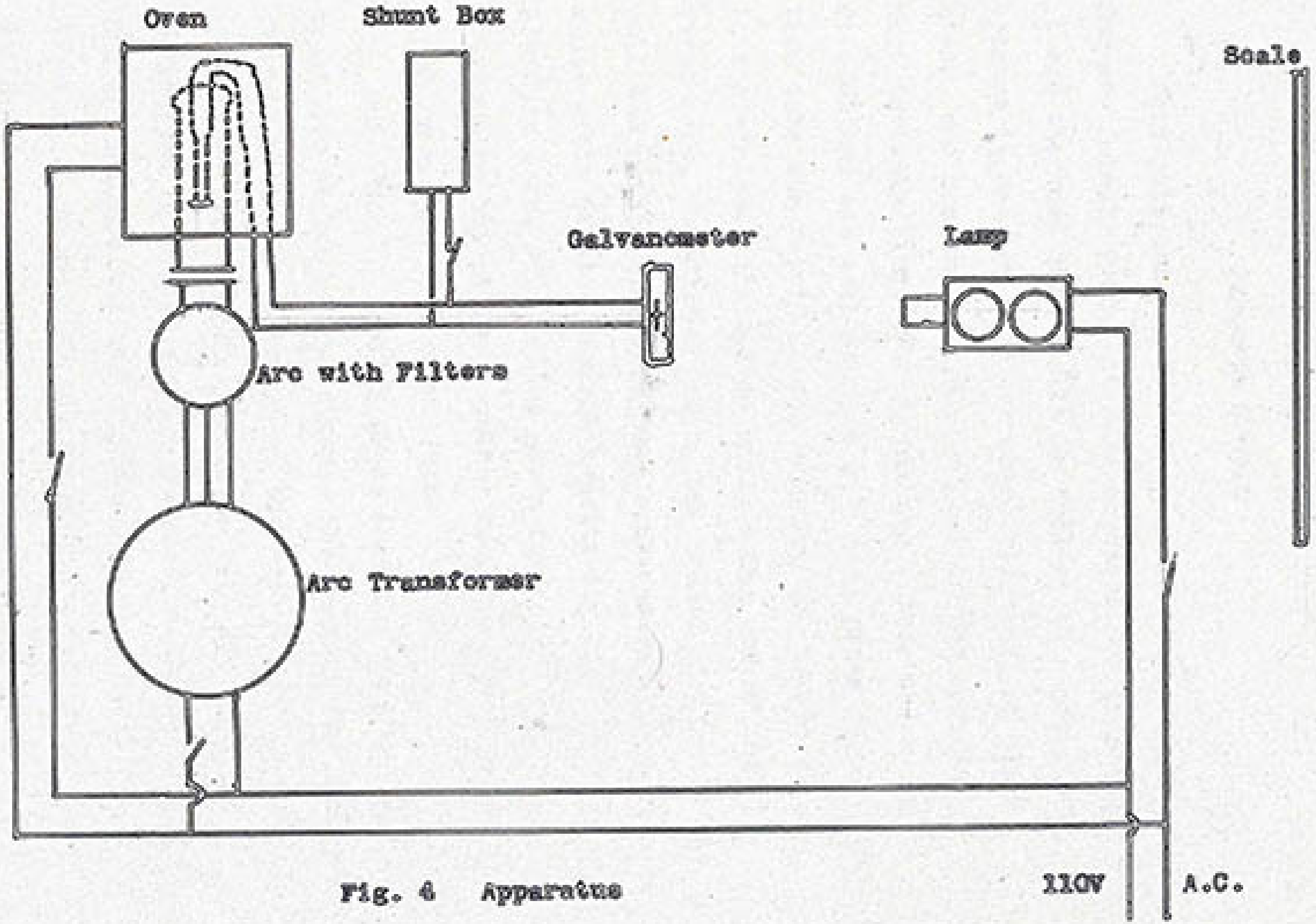


Fig. 4 Apparatus

CELL #2

Japanese Sample

This cell belongs to the original group constructed for preliminary work, and data is given for it because it was the most characteristic cell of this group, and because it was the most characteristic cell of this group, and because it was also used in the radiant heat investigation. The sample was rather thick and fibrous and was well mounted on a long glass stem. The test tube was fairly short, bringing the sample close to the window. The bottom seal, being one of the first made, was rather rough, but seemed airtight. The cell was rather sensitive when constructed, but lost quite a bit of its original sensitivity during the preliminary work. The tables given for this cell are fragmentary and pieced together from the observations taken on several different days.

Reference to table I shows that the cell was most sensitive at room temperature. The sensitivity rapidly dropped as the temperature of the oven was raised, the unfiltered arc producing only the faintest trace of a deflection at 100°. The temperature was raised to 300°, but at no place was the sensitivity again manifest. However, at these high temperatures, a very large heat deflection was noticed. At this point, it is interesting to point out the large heat deflections in the radiant heat test on this cell. This test bears out the conclusion that the deflection produced by the oven's heat was due to thermal radiations, and not to any thermo-electric effects due to temperature differences among the elements of the cell.

It was noticed in the preliminary tests that either the heat or the light deflection was reversed upon evacuation. It was not known at that time which deflection was reversed, due to the fact that insufficient data was recorded at the time of the experiment. During the course of the radiant heat investigation, it was discovered that the heat deflection reversed in the evacuated condition, and became less intense in the reverse direction. It is to be inferred that it was the heat deflection that reversed in the original test.

In all tests, the cell showed a noticeable proportionality of deflection to temperature of cell. The unfiltered arc in all cases produced the greatest deflection outside of the heat deflection. Next in order come the blue, yellow, and green. Of course, the unfiltered arc projected much more energy on the cell than any of the other colors, and green projected the least energy. The blue probably transmitted more energy than the yellow.

This cell was tried with the monochromatic illuminator in various ways. No results whatsoever could be obtained from it before evacuation, and after evacuation, there were a few slight reaction to the strongest lines, which, however, were so weak and uncertain that any definite success was dispaired of. The largest deflection was obtained with the 5450Å line and amounted to nearly 2 millimeters, but the galvanometer would not return immediately to zero after exposure.

TABLE I

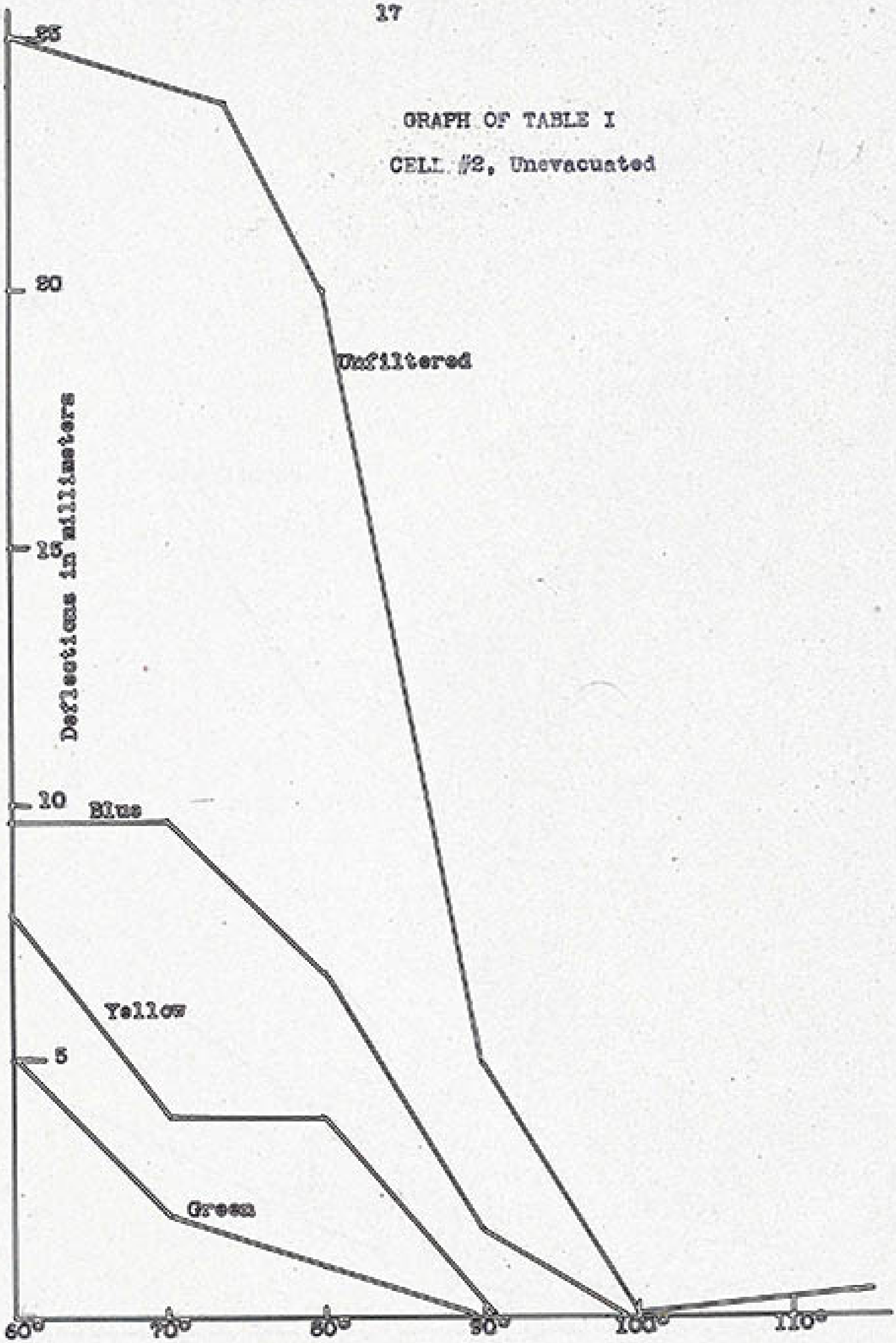
Cell #2 Unevacuated (Japanese Sample)

Temp.	Heat	Green	Yellow	Blue	Unfiltered
		Deflection in millimeters			
Room		17	30	40	150
115°	210	0	0	0	0
100°	250	0	0	0	Trace
95°		0	0	2	5
80°		2	4	7	20
70°	100	2	4	10	25
60°	64	5	8	10	25

TABLE II

Cell #2 Evacuated (Japanese Sample)

Temp.	Heat	Green	Yellow	Blue	Unfiltered
		Deflection in millimeters			
Room		55	112	19	285
110°	-75	3	13	4	38
100°	-130	1	1	5	25
60°	-57	18	27		75


GRAPH OF TABLE I
CELL #2, Unevacuated
Deflections in millimeters
25
20
15
10
5
Unfiltered
Blue
Yellow
Green
60°
70°
80°
90°
100°
110°

GRAPH OF TABLE II

CELL #2, EVACUATED

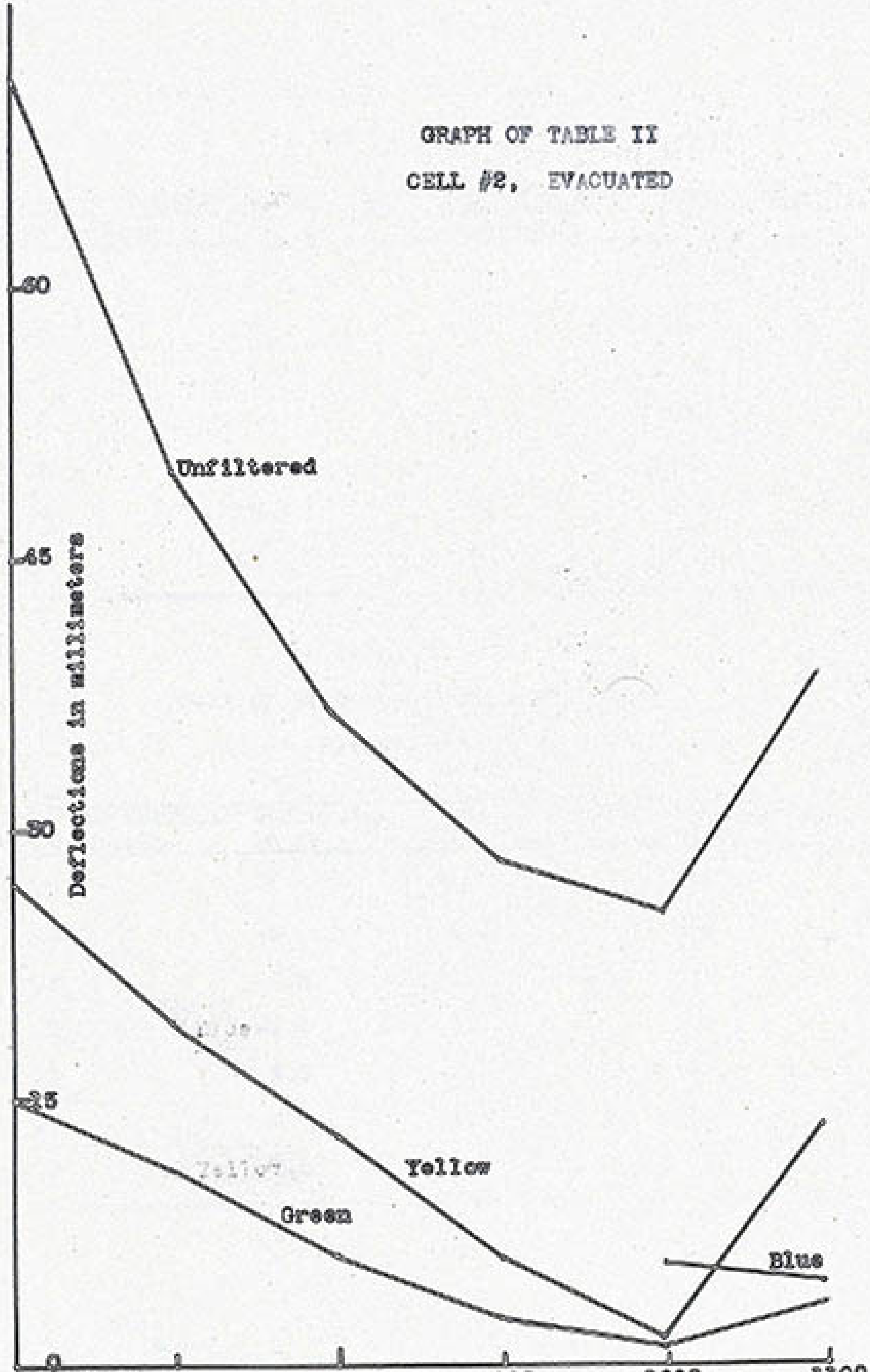


TABLE III

Cell #2 Unevacuated (Japanese Sample)

Radiant Heat

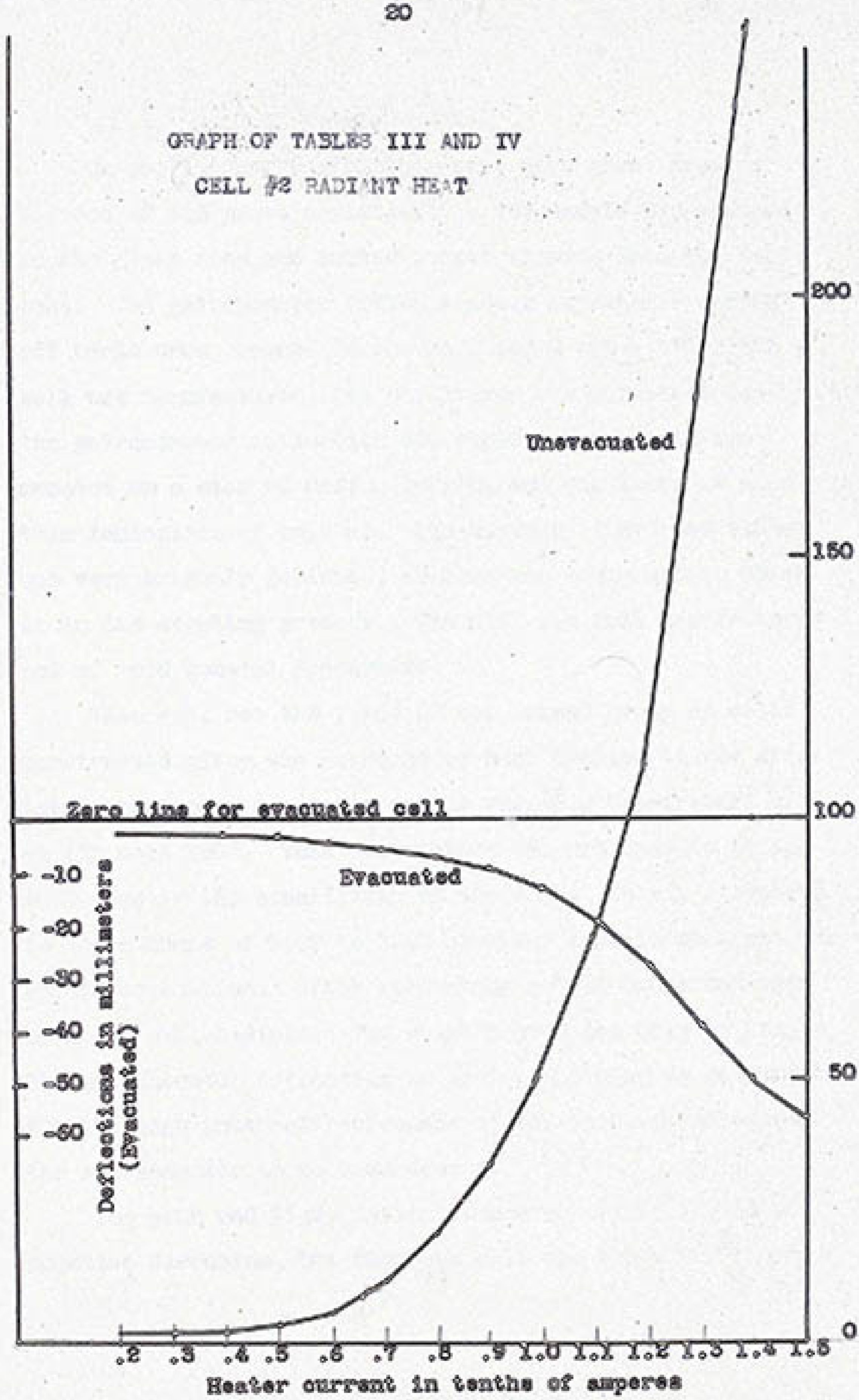
Heater Current in amperes	Deflection in mm	Heater Current in amperes	Deflection in mm
.2	1	.9	35
.3	8	1.0	51
.4	1.5	1.1	75
.5	4	1.2	115
.6	15.5	1.3	191
.7	12	1.3	250
.8	22	1.5	325

TABLE IV

Cell #2 Evacuated (Japanese Sample)

Radiant Heat

Heater Current in amperes	Deflection in mm	Heater Current in amperes	Deflection in mm
.2	-2	.9	-8.5
.3	-2	1.0	-12
.4	-2.3	1.1	-18
.5	-2.5	1.2	-28
.6	-3.5	1.3	-38
.7	-5	1.4	-50
.8	-7.5	1.5	-58


GRAPH OF TABLES III AND IV
CELL #2 RADIANT HEAT
Unevacuated
Zero line for evacuated cell
Evacuated
200
150
100
50
0
-10
-20
-30
-40
-50
-60
Deflections in millimeters (Evacuated)
Deflections in millimeters (Unevacuated)
.2 .3 .4 .5 .6 .7 .8 .9 1.0 1.1 1.2 1.3 1.4 1.5
Heater current in tenths of amperes

CELL #6

N.Y. Sample

In preliminary tests, this cell gave great promise because of its great sensitivity. The sample was mounted on the glass stem and tested before blowing into the test tube. The galvanometer deflection was repeatedly thrown off scale when exposed to the unfiltered arc. After the cell was manufactured, the unfiltered arc continued to throw the galvanometer deflection off scale. The sample was mounted on a stem of medium length, and consisted of a single thin lamination of crystal. The surface toward the window was very brightly polished, as care was taken not to touch it in the mounting process. The cell was well manufactured and of good general appearance.

This cell was the first of the second group of cells constructed after the overdose of heat applied to the first lot. Great care was taken not to exceed a temperature of at the most 120°. This temperature did not seem to permanently impair the sensitivity of the cell. It was necessary to use a shunt of 1000 to 1300 ohms for certain observations before evacuation. After evacuation a 7000 ohm shunt was used for all readings. The shunt served not only to keep the galvanometer deflection on scale, but also to compensate for the high internal resistance of the cell, which caused the galvanometer to be underdamped.

The heat and light deflections were originally in the negative direction, but when the cell was evacuated the heat deflections became uniformly positive and much stronger. The actino deflections were also increased by evacuation but remained negative in direction.

TABLE V

Cell #6 Unevacuated (N.Y. Sample)

Temp.	Heat	Green	Yellow	Blue	Unfiltered
		Deflection in millimeters			
Room		-235	-81##	-140##	-210##
120°	-4	-34	-67	-140	-222
100°	-1.5	-51	-115	-112	-390
90°	-1.5	-59	-163	-184	-740#
80°	-3	-80	-175	-200	-940#
70°	-3.5	-118	-285	-325	-130#
60°	-3	-125	-224	-316	-157#

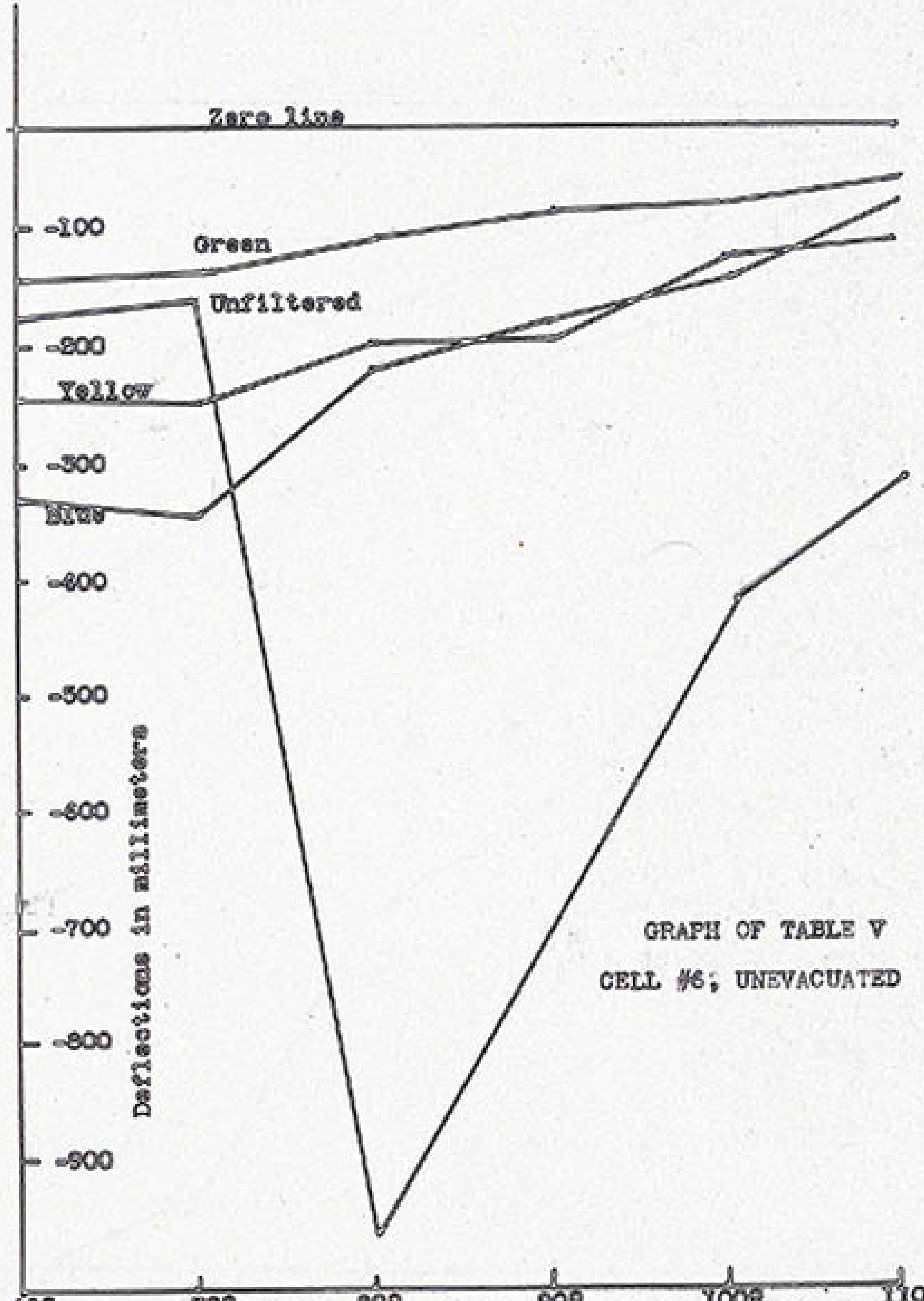
1000 ohm shunt   ## 1300 ohm shunt

TABLE VI

Cell #6 Evacuated (N.Y. Sample)

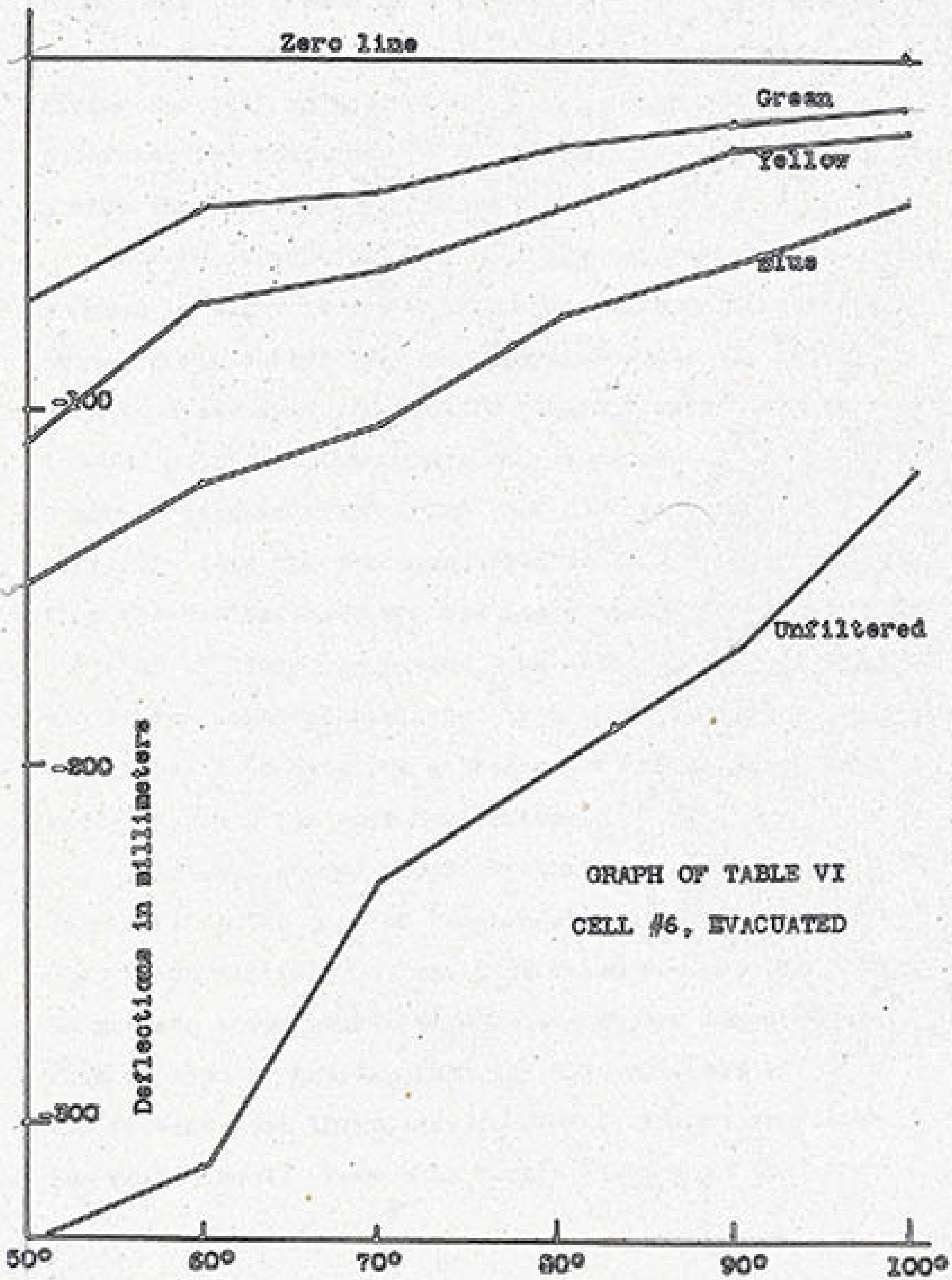
Temp.	Heat	Green	Yellow	Blue	Unfiltered
		Deflection in millimeters			
Room		-86	-167	-280	-400
100°	-1	-14	- 30	-40	-120
90°	7	-23	-48	-65	-168
80°	6	-31	-61	-79	-206
70°	4	-41	-73	-104	-236
60°	1	-45	-110	-119	-317
50°	-1	-62	-110	-157	-330

In test of Table VI, a 7000 ohm Galvanometer shunt was used.



GRAPH OF TABLE V

CELL #6; UNEVACUATED


Zero line
Green
Yellow
Blue
Unfiltered
-100
-200
-300
Deflections in millimeters
50°
60°
70°
80°
90°
100°
GRAPH OF TABLE VI
CELL #6, EVACUATED

CELL #G

N.Y. Sample

A long stem mounting was used for this cell. The sample was cut from a thin lamination of crystal with the original polish retained. One contact was rather poor, giving the cell an unusually high internal resistance. Otherwise the construction of the cell was good, giving it a nice external appearance.

Before evacuation, the cell was not very stable. When exposed to light it would cause the galvanometer to start swinging violently. The galvanometer would not settle down to a steady deflection so readings were taken by noting the end points of the swings and averaging them mentally. A shunt resistance was tried, but any resistance that would correctly damp the galvanometer also took so much current that the deflections were not large enough to be read with certainty. After evacuation, the cell became more sensitive, and it was found possible to use a shunt resistance of a low enough value to damp the galvanometer and still provide enough current for good deflections.

This cell showed peculiar behavior in being more sensitive at the highest temperatures used than it was at room temperature. The heat deflection was greater at intermediate temperatures than at the higher temperatures. This is also a peculiar result. This cell was tried in the radiant heat investigation, and found not sensitive to radiant heat. From this result it appears that the heat deflection might be due to temperature differences between the elements of the cell. In the several tests run on this cell, very little uniformity was found among similar observations taken on different days. This fact also bears out the same conclusion. It is also to be conjectured that possibly the erratic light deflections secured before evacuation might be due to the warming effect of the light on various elements of the cell. The fact that the cell became more sensitive at higher temperatures in contrast with all the other cells tested seems to be in accord with this hypothesis.

After the cell was evacuated, a shunt of 10,000 ohms was used across the galvanometer and steadier deflections were obtained. The cell was still more sensitive at higher temperatures, but to a much less degree. There was probably more of an actino component in the output of the cell after evacuation. The evacuation probably made it more difficult for temperature differences to exist between the elements of the cell, and also removed the hinderance of the air molecules on photo-electrons ejected from the crystal.

TABLE VII

Cell #8 Unevacuated (N.Y. Sample)

Temp.	Heat	Green	Yellow	Blue	Unfiltered
		Deflection in millimeters			
Room		6.0	5.0	8.0	12.0
100°	-7	12.5	25.0	50.0	65.0
90°	-7	10.0	32.0	20.0	57.0
80°	-6	7.5	21.0	32.0	65.0
70°	-7	9.0	30.0	26.0	95.0
60°	-9	7.5	25.0	51.0	50.0
50°	-8	5.0	37.0	30.0	15.0

TABLE VIII

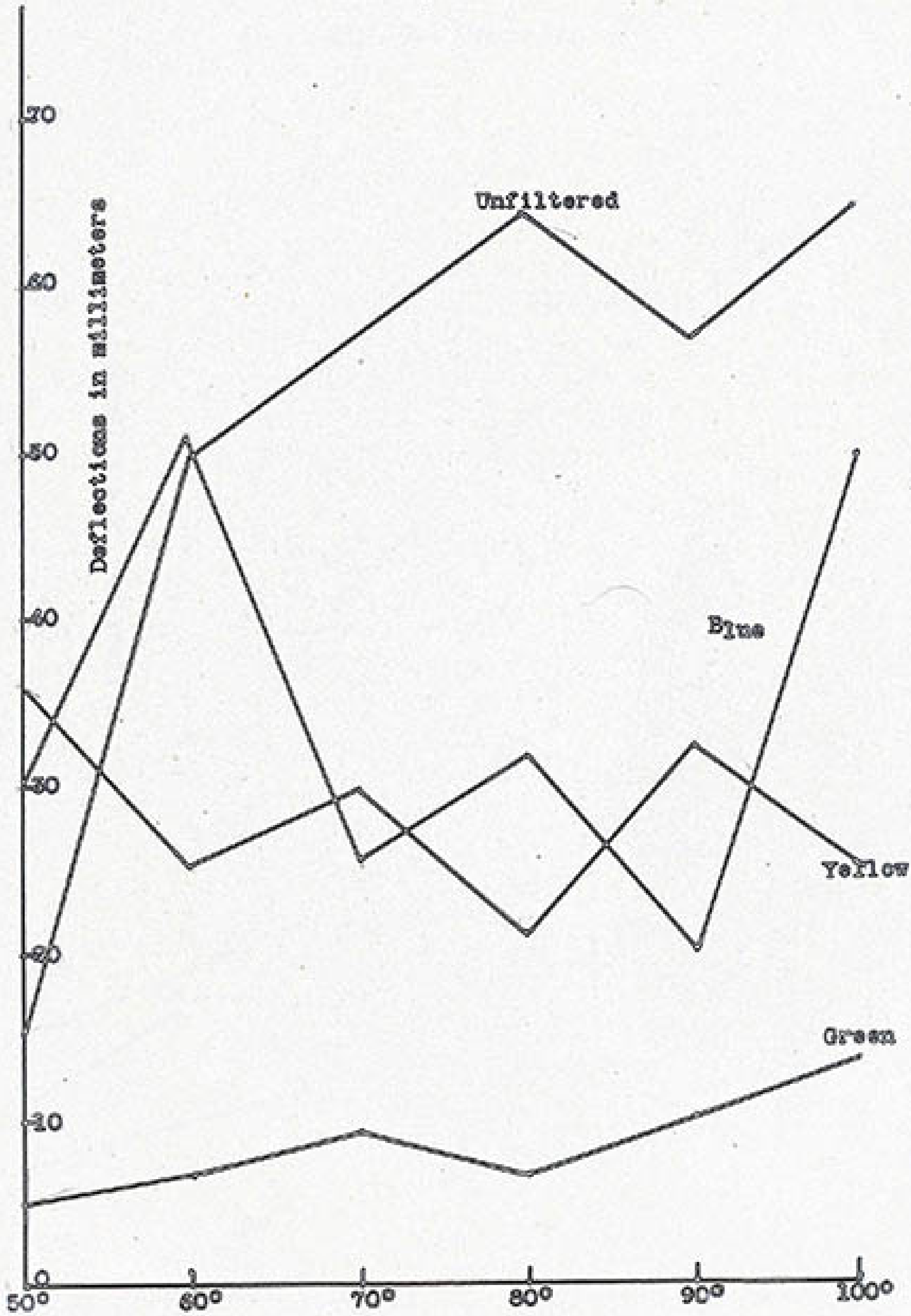
Cell #8 Evacuated (N.Y. Sample)

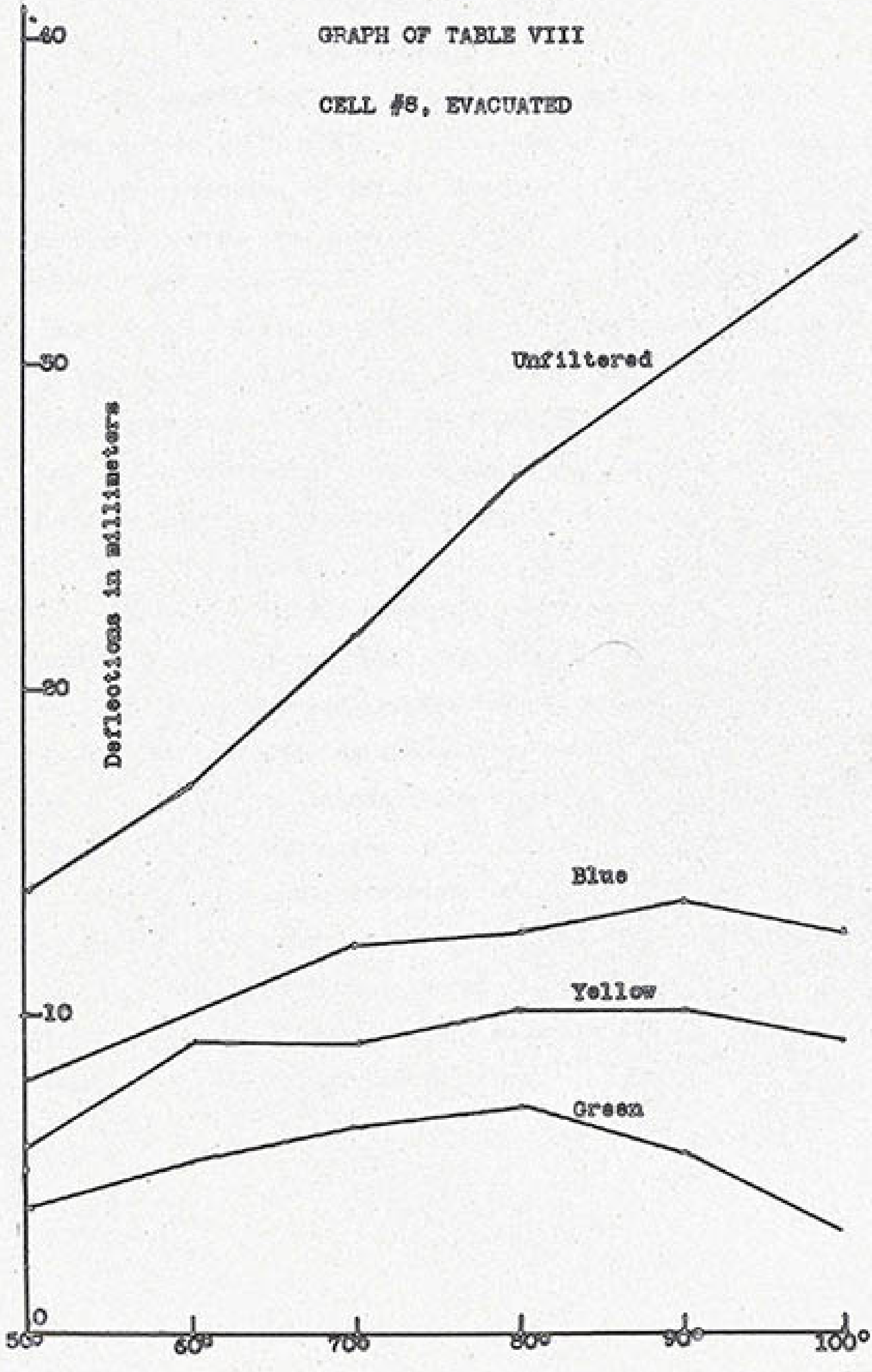
Temp.	Heat	Green	Yellow	Blue	Unfiltered
		Deflections in millimeters			
Room		6.5	8.5	9.5	12.0
100°	-1.5	3.0	8.0	12.5	33.0
90°	-1.5	5.5	10.0	13.5	30.0
80°	-2.0	7.0	10.0	12.5	27.5
70°	-2.5	6.5	9.0	12.0	22.5
60°	-2.5	5.5	9.0	10.0	17.0
50°	-3.0	4.0	6.0	8.0	14.0

Test in Table VIII was run with 10,000 ohm galvanometer shunt for stability.

GRAPH OF TABLE VII

CELL #8, UNEVACUATED




GRAPH OF TABLE VIII
CELL #8, EVACUATED
40
30
20
10
0
Deflections in millimeters
Unfiltered
Blue
Yellow
Green
50°
60°
70°
80°
90°
100°

CELL #9

Canadian Sample

The sample consists of a thin lamination of crystal, cracked across the middle. It is mounted on a short stem and shows evidence of having been pretty hot in the process of manufacture. The asbestos mount is discolored with the heat of the flame used to make the cell. On account of the short stem, the sample is farther from the window than any of the other cells. Several cells were constructed with a short stem similar to this one, but all were total failures with this exception. I attribute this to the excessive heating which the sample undergoes in the process of manufacture of the cell.

This cell was not extremely sensitive, but was quite steady in its deflections. There was a marked decrease in sensitivity as the temperature was raised. The sensitivity at all temperatures was enhanced by evacuation of the cell. No radical changes in direction of deflection was noticed in this cell upon evacuation as in some of the other cells.

The steady characteristics of this cell may be attributed to its comparatively low internal resistance. The galvanometer was well damped with no external shunt in the circuit. A cell of this type is desirable where accurate readings are to be taken over a period of several days.

TABLE IX

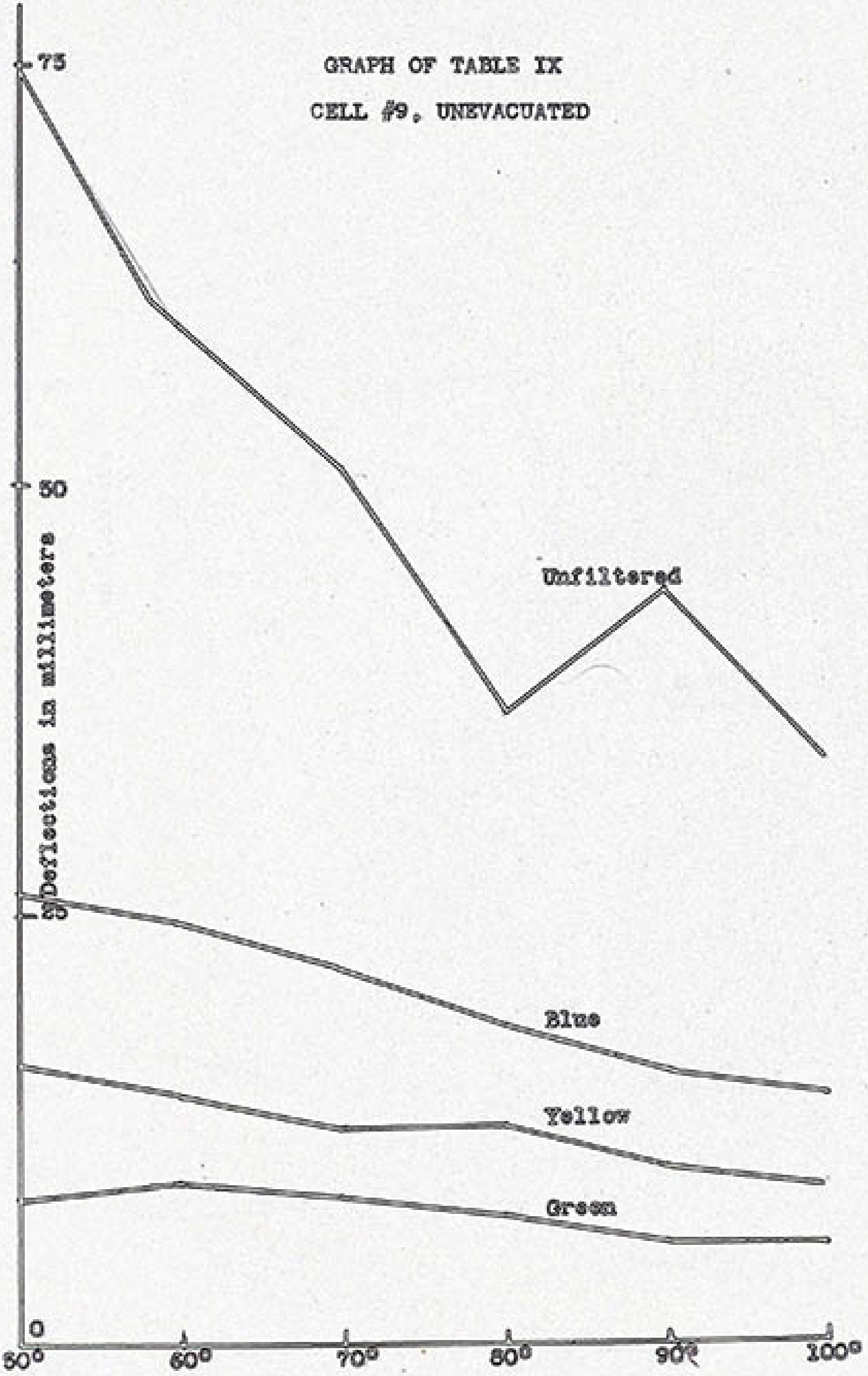
Cell #9 Unevacuated (Canadian Sample)

Temp.	Heat	Green	Yellow	Blue	Unfiltered
		Deflection in millimeters			
Room		10	17	30	63
110°	2.5	5	7.5	10	32
100°	.5	6	9.5	15	34
90°	-1.0	6	11	17	44
80°	-2.5	7.5	13	19	38
70°	-3.5	8.5	15	23	52
60°	-3.5	9	15	25	59
50°	-5	8.5	17.5	27	75

TABLE X

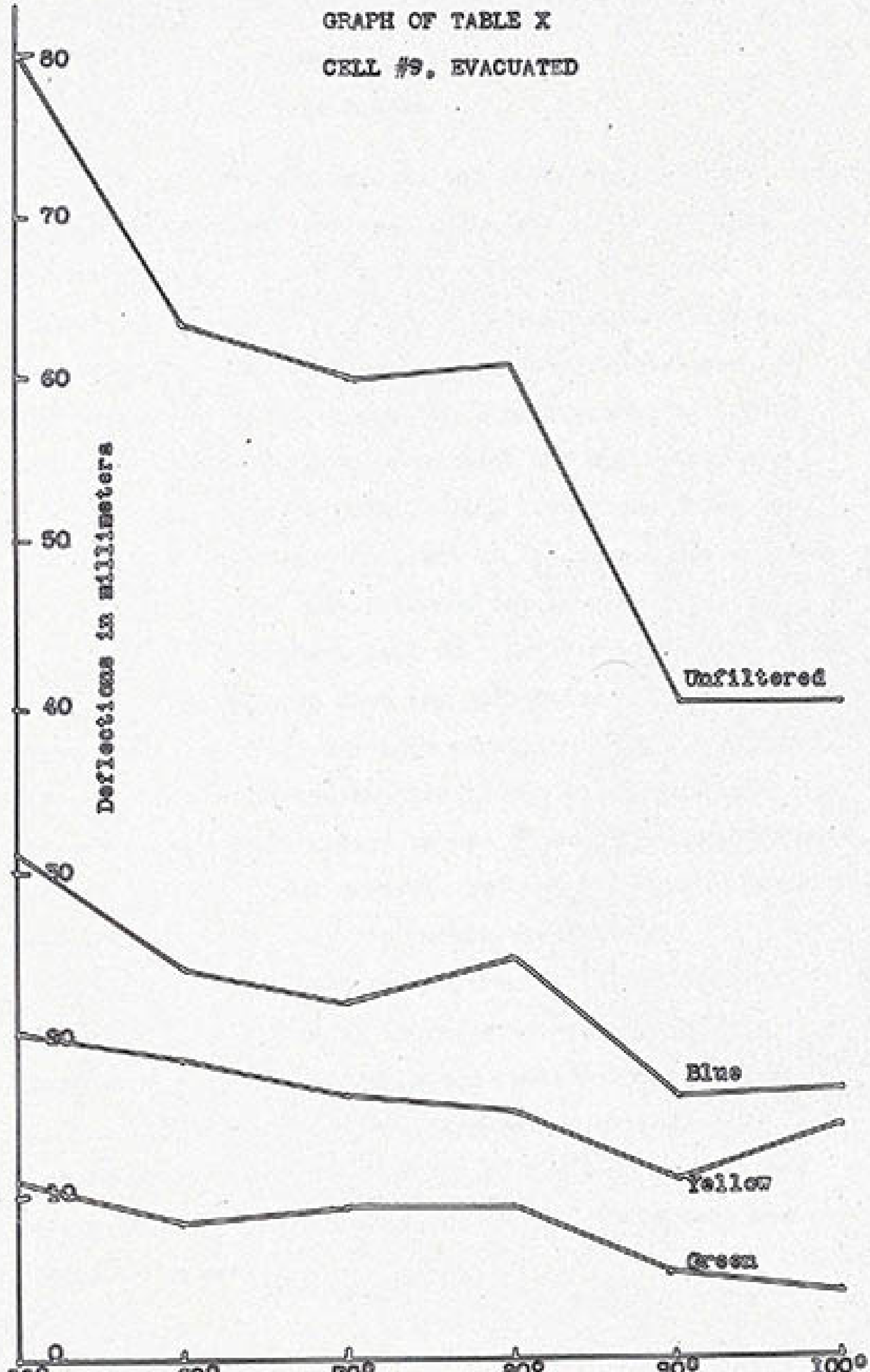
Cell #9 Evacuated (Canadian Sample)

Temp.	Heat	Green	Yellow	Blue	Unfiltered
		Deflection in millimeters			
Room		18	34	39	102
100°	-8	4	14	16.5	41
90°	2	5	11	16	41
80°	0	8	15	24	61
70°	-2	8.5	16	22	60
60°	-2.5	7.5	17.5	24	63
50°	-3.5	11	20	31	82


GRAPH OF TABLE IX
CELL #9, UNEVACUATED
75
50
25
0
Deflections in millimeters
Unfiltered
Blue
Yellow
Green
50°
60°
70°
80°
90°
100°

GRAPH OF TABLE X

CELL #9, EVACUATED



CELL #10

N.Y. Sample

This cell was not used in the light experiments because the exhaust stem was broken off in the process of manufacture. It was used in a radiant heat test because the broken stem could be closed with sealing wax for this test. The sample was dull colored, but was well mounted on a long stem. In a preliminary trial the cell gave a deflection of 45 mm with the unfiltered arc with no window over the cell. This test proves that the cell would be sensitive to light of the same tests applied to the other cells. The cell was not as sensitive to radiant heat as Japanese cell #2. However, it is interesting to note that the deflection reversed on evacuation. The cell was more sensitive in the reverse direction after evacuation than it was in the positive direction before evacuation in the sense that the deflections started at lower current, but they did not rise so high at the end as they did before evacuation.

It is probable that the reversal of direction was due to the interaction of thermo-electric and actino-electric reactions. During these radiant heat experiments it was much more likely that temperature differences existed between various elements of the cell than it was during the light experiments, where the entire cell was heated in an oven.

TABLE XI

Cell #10 Unevacuated (N.Y. Sample)

Radiant Heat

Heater Current in amperes	Deflection in mm	Heater Current in amperes	Deflection in mm
.2	0	.9	0
.3	0	1.0	1
.4	0	1.1	3
.5	0	1.2	6
.6	0	1.3	10
.7	0	1.4	16
.8	0	1.5	22

TABLE XII

Cell #10 Evacuated (N. Y. Sample)

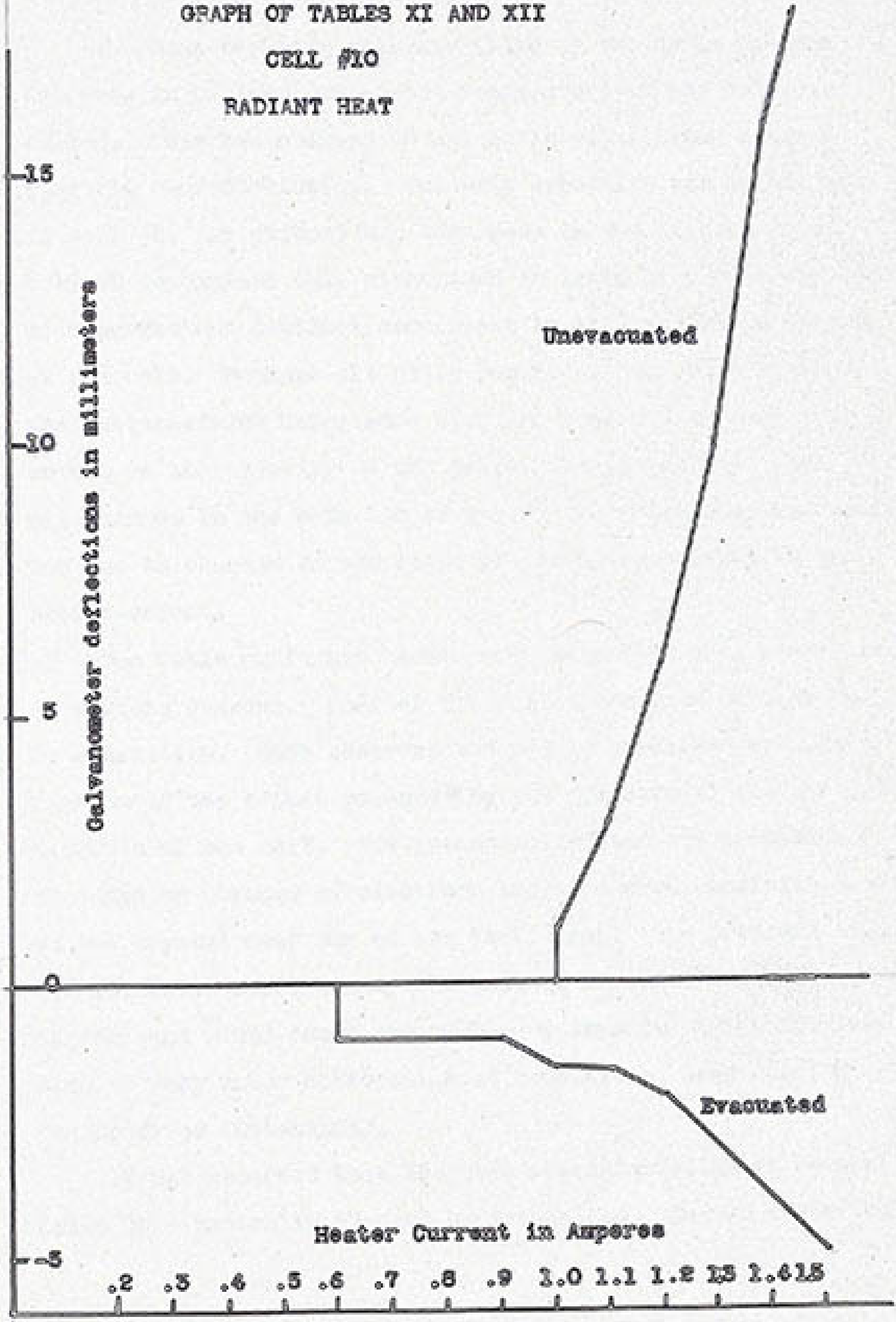
Radiant Heat

Heater Current in amperes	Deflection in mm	Heater Current in amperes	Deflection in mm
.2	0	.9	-1
.3	0	1.0	-1.5
.4	0	1.1	-1.5
.5	0	1.2	-2
.6	-1	1.3	-3
.7	-1	1.4	-4
.8	-1	1.5	-5

GRAPH OF TABLES XI AND XII

CELL #10

RADIANT HEAT



GENERAL OBSERVATIONS

The most striking characteristic of the cells was the decrease in deflections as the temperature of the cell was raised. This was noticed in all cells with strong actino-electric characteristics. The only exception was in the case of cell #8. An attempt has been made in the discussion of cell #8 to explain this phenomenon in terms of the interaction of separate and distinct components in the electrical output of the cell. Perhaps all cells behaved along these lines; the actino-effect being much stronger than the thermo-effect in the majority of the cells. It is possible that all changes in the behavior of any of the cells upon evacuation was due to changes in the ratio of the thermo-effect to the actino-effect.

The cells uniformly became more sensitive upon evacuation in various degrees. Some of the cells were made more stable by evacuation. Both observations may be explained by consideration of the effect produced by the pressure of the air on the elements of the cell. The actino-deflection was probably produced by streams of electrons shot out from sensitive spots on the crystal near one of the lead wires. The pressure of air molecules would hinder the passage of the electrons to some degree, and would cause the number of them to strike the lead wire to vary under different heat conditions, thus causing the observed instability.

It was observed that the heat characteristics of several cells were radically changed by evacuation. In two cases the deflection was actually reversed. The presence of atmospheric pressure in the cell would probably tend to enhance the thermo-component of the heat deflection at the expense of the actino-component. This would be due to the absorption of radiant heat rays from the walls of the cell by the air, and also to the hindering influence on the electron streams. After evacuation, radiant heat rays from the walls of the cell would go unhampered to the sample and the electron streams would not be deflected by the air pressure.

Much larger deflections were always obtained from the unfiltered arc than for any of the filter arrangements. This is to be expected because of the much larger energy content of this form of light. The blue filter cut off the longer wavelengths and probably passed slightly more energy than the yellow filter, which cut off the shorter wavelengths. The green filter passed only the green doublet at 5461Å and probably projected much the least energy on the cell of any of the filters. The deflections run pretty much in the order of the energy content of the incident light. The blue filter gave larger deflections than the yellow, which in turn gave larger deflections than the green.

Some slight tendency in some of the tests was noticed for a positive deflection to be produced by one color and a negative deflection for another. This phenomenon was noticed in the preliminary tests on several samples before they were mounted in cells. These characteristics never became apparent after the cell was manufactured. This phenomenon would be rather difficult to explain without the consideration that there were sensitive spots on the surface of the cell near the lead wires which vary among themselves for various colors.

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