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MONSANTO CHEMICAL COMPANY
DAYTON, OHIO

M. M. HARING, LABORATORY DIRECTOR
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ACUTE EXPOSURE TO POLONIUM
(Medical Study of Three Human Cases)

Date: March 4, 1948
Distributed: APR 2 - 1948

Prepared by:
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Lt. Col., M.C. (A.E.C.)

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This report was prepared by D. H. Naimark, Chief, Medical Branch, A. E. C., Dayton Area. Evaluations of the findings are those of the author.

Approved by M. M. Haring
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ABSTRACT

Three Chemists were inadvertantly exposed to polonium. It is believed that the exposure occurred during the transfer of a hot solution from a leaking kettle to a carboy, the route of contamination being by inhalation. It is calculated that Chemist A could have received a maximum dose of 10 uc in the body (0.13 uc/kilogram); Chemist B, a maximum dose of 11.8 uc in the body (0.19 uc/kilogram); and Chemist C, a maximum dose of 88.1 uc in the body (1.14 uc/kilogram). Forcing fluids so that there is increased urine excretion apparently was not an influencing factor in the rate of activity excretion. No evidence of kidney damage due to polonium has been detected to date. Although there is a suspicion that some sub-clinical depression of the hematopoetic system may have occurred as a result of the exposure in Chemists B and C, the data available, to date, are insufficient to support a definite statement to that effect.

DETAILED REPORT

On this project, all operating personnel submit urine specimens once each week for alpha activity analysis. The level of activity in the urine is used as an indication of the amount of radioactive polonium in the body. The permissible allowance level (PAL) for personnel is 12 c./min./50 ml. of urine or 500 d./min./24 hour urine volume. This level was adopted on April 1, 1946, being based on the recommendations made by a committee of four health and medical authorities associated with the Manhattan Project. Any individual who excretes activity above this PAL is restricted from working with active material until his excretion is again below this rate.

Activity determinations on the routine weekly urine samples submitted on January 20-21, 1947, revealed that Chemists A, B and C had exceptionally high counts of 174, 734 and 2190 c./min./50 ml., respectively. These high counts were verified by tests on new samples. The urine counts of these three Chemists submitted on January 13, 1947, were all within the 12 c./min./50 ml., permissible level.

An investigation was immediately launched to determine the source of the exposure, since there was no report of a spill or accident involving active material. Chemists A and B were assigned to the old Process Laboratory. Chemist C was the supervisor of this laboratory and the Marlite Room, spending some of his time in each. Since no other personnel developed high counts, it is assumed that the source of the exposure was from the old Process Laboratory, that all three Chemists were probably exposed at the same time, and that the exposure occurred some time during the working days of January 13-17, inclusive.

Operators of hand counters who conduct wipe tests on all personnel leaving the plant, both at the lunch hour and at the termination of the work day, did not report that any of the three Chemists were required to return to the washroom to decontaminate their hands during this period. It is believed, therefore, that the route of contamination was by inhalation and not ingestion; although the latter possibility is not conclusively eliminated.

A study of the activity air levels in the Process Laboratory was made. The two 8-hour air samplers in the lab showed air levels to be within the permissible limits for the period except for January 17 when one was 3.9 and the other 2.5 times the PAL of 2400 d./min./cu. meter of air.

Operations conducted in the Process Laboratory during the period January 13-17 were reviewed. January 13, Chemist A was the only man assigned to the laboratory and he devoted his time to cleaning equipment. On the morning of January 14, Chemists A and B started the denitration of a polonium solution in a small kettle inside a hood. About 30 minutes after the onset, Chemist A noted that the kettle was leaking and immediately ceased operations. He notified Chemist C (the supervisor), and it was decided to transfer the active solution from the kettle, so that the latter could be repaired. Chemists A and B donned respirators, smocks over their coveralls, and rubber gloves and proceeded to transfer the solution to a carboy placed in the hood. A vacuum was drawn on the carboy, and the solution thereby transferred to it from the kettle. The kettle was then rinsed several times with hydrochloric acid and the transfer was completed. Chemist C was present during these operations. He took no active part in the transfer, but stood back of the operators, without a respirator, observing and supervising the work.

The afternoon of January 14 and during January 15, maintenance personnel disassembled, repaired, and reinstalled the kettle; and a clean-up crew conducted decontamination procedures. None of these men developed high urine counts.

On January 16 and 17, Chemists A and B, and a Chemist D proceeded with the denitration in the repaired kettle and conducted other operations with the active solution. Chemist D did not develop a high urine count.

From all the above, no definite statement can be made as to the immediate cause of the contamination of the Chemists. The high air sample levels of January 17 are not of sufficient degree to make one suspect them as the source. The clean-up and maintenance procedures during the week caused no increase in the urine counts of the operating personnel and, therefore, seem unlikely to have caused the high counts in the Chemists. The processing carried on during the last two days of the week also appears to be ruled out, since Chemist D was not affected.

By the process of elimination, the time of exposure seems to be narrowed down to the morning of January 14, when the kettle containing the active solution developed a leak and the solution was transferred to the carboy. All three Chemists concerned were present during the transfer period. Chemists A and B wore respirators, but these could have been donned improperly so that there was leakage or the respirators may not have been 100 per cent efficient. Chemist C did not wear a respirator. This could account for the fact that he received a much greater amount of contamination than Chemists A and B. This explanation is suggested from the information available and, although not conclusive evidence, is suspected of being the method of exposure.

All three Chemists were restricted from working in areas where active materials were present and assigned to positions which experience has shown would normally not raise the urine counts. The men were instructed to increase their fluid intake to a maximum.

A medical study of each case was instituted. Difficulty was encountered in obtaining sufficient samples of feces and blood for activity analyses, and the few samples analyzed are not reported, as no significant evaluations could be made from same. However, spot and 24-hour urine specimens were collected and analyzed for activity; and semi-monthly blood counts and monthly urinalyses were performed. The results of these tests are reported in the following charts:

Chart 1 - Urine activity analyses - Chemist A

Chart 2 - Urine activity analyses - Chemist B

Chart 3 - Urine activity analyses - Chemist C

Chart 4 - Graph of activity excretion in urine per day - Chemist A

Chart 5 - Graph of activity excretion in urine per day - Chemist B

Chart 6 - Graph of activity excretion in urine per day - Chemist C

Chart 7 - Routine urinalyses - Chemist A, B, and C

Chart 8 - Blood counts - Chemist A

Chart 9 - Blood counts - Chemist B

Chart 10 - Blood counts - Chemist C

Chart 11 - Graph of WBC counts - Chemist A

Chart 12 - Graph of WBC counts - Chemist B

Chart 13 - Graph of WBC counts - Chemist C

An attempt at determining the maximum possible amount of polonium received by each Chemist was made. The calculations were based on the highest of the first few spot sample urine counts obtained per individual. Chemist A's highest count was 264 c./min./50 ml. on February 11 (3rd sample, the late date being due to the fact that this man was out of the state on emergency leave for about three weeks). Assuming that the average individual excretes 1050 ml. of urine per 24-hour day, on February 11, the total activity excretion/day = $264 \times \frac{1050}{50} = 5544$ c./min./day.

Using the decay curve formula, $N_t = N_o e^{-\lambda t}$, we can figure back to January 14 (the suspected date of exposure) by substituting the known values and solving the formula for N_o. The known values are:

N_t = 5544 c./min./day

$\lambda = \frac{.693}{T}$

T = 28 days (explained later)

t = 28 days (January 14 - February 11)

$N_t = N_o e^{-\lambda t}$, which solved for N_o is

$N_o = N_t \times \text{antilog}_e \lambda t$

Substituting the known values,

$$N_o = 5544 \times \text{antilog}_e \frac{0.693\, t}{T} = 5544 \times \text{antilog}_e \frac{0.693 \times 28}{28}$$

= 5544 x 2 = 11,088 or approximately 11,000 c./min./day

11,000 multiplied by 2 = 2.2×10^4 d./min./day

Assuming again that 0.1 per cent of the polonium in the body is excreted in the urine per day, we get $2.2 \times 10^4 \times 10^3$ = 2.2×10^7 d./min. from the polonium in the body. By definition, there are 2.22×10^6 d./min. per microcurie, therefore, $\frac{2.2 \times 10^7}{2.22 \times 10^6}$ = approximately 10 microcuries of polonium in the body as the maximum possible dose. Chemist A weighs 72.7 kilograms (160 lbs). It is calculated, therefore, that a maximum dose of 0.13 uc/kilogram could have been received by this man.

Chemist B's highest count was 734 c./min./50 ml. (1st sample submitted January 20.) Calculating as above, we obtain a figure of 11.8 uc of polonium as the maximum amount in the body. Chemist B weighs 61.3 kilograms (135 lbs). The maximum acute dose is, therefore, 0.19 uc/kilogram.

Similarly, using Chemist C's highest count of 3615 c./min./50 ml. (4th sample January 24) we get a figure of 88.1 uc of polonium in the body. Chemist C's weight is 77.27 kilograms (170 lbs). We, therefore, calculate a maximum acute dose of 1.14 uc/kilogram.

From the data in Charts 1, 2, and 3, graphs were prepared for each individual, plotting the amount of activity excreted in the urine per day against time. Previous data seem to indicate that the biological half-life of polonium is no greater than about 30 days, and a figure of 25 days has been generally accepted. For ease in graphing, a 28-day half-life was assumed and the anticipated reduction of urine activity was plotted.

Inspection of the graphs (Charts 3,4, and 5) reveals that there was an actual delay of return to the PAL ranging from 1-5 weeks after the expected date. This data might lead one to suspect that the body half-life was greater than 28 days. This delay, however, could be explained by the fact that, although the Chemists were restricted from working with activity and assigned to duties in relatively clean areas, still these areas are adjacent to operating laboratories. Though the air levels here are, as a rule, well below the PAL, they are, nevertheless, well above normal background for alpha activity. During the months of working in these areas, the Chemists could have inhaled or ingested enough activity to account for the delay in returning to the PAL. It is felt that this possibility is the more likely one to explain the delay, and that the assumed biological half-life is approximately correct.

From the figures obtained on the total volumes of urine excreted per day, it is evident that in general all three men co-operated quite well with the instruction to force fluids. It was hoped that the increased urine output would result in an increased excretion of activity so that the individuals would more rapidly return to the PAL. The actual activity excreted and the delay in returning to the PAL in all three cases, however, did not substantiate this hypothesis. There was, also, no evidence of a relative increase in per cent of excretion of activity (based on total activity in the body) early in the course of this study with a relative decrease later. It appears, therefore, that in these cases the rate of excretion of activity was independent of the daily urine volume.

A study of the urinalyses reports reveals no significant abnormal findings. It can be stated that, to date, no evidence of kidney damage has been found in any of the three men.

Analysis of the blood counts (Charts 8,9, and 10) reveals no definite abnormal findings. It is of interest to note, however, that in the case of Chemist B (Chart 12), all WBC counts from the period starting approximately six weeks after the exposure to the present time have been under 7000, with five samples being below 5000. It is to be noted, also, that in the case of Chemist C (Chart 13), where only one of seven WBC counts taken in the 18-month period prior to the acute exposure was below 7500, practically all the counts since then have been under 7000.

Whether one can assume that there has been some sub-clinical depression of the hematopoetic system of these two men from the meager evidence presented is a matter of conjecture. Certainly, at this time, the data are considered insufficient to support such a statement.

Chemist A is still employed at this site and is being followed with routine examinations. Chemists B and C have recently terminated their employment. Attempts at a follow-up study of these two individuals are being made.

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CHART 1

URINE ACTIVITY ANALYSES UNCLASSIFIED
CHEMIST A

Sample No.	Date 1947	Spot Sample c./min./50ml.	24-hour Sample Average c./min./50ml.	24-hour Sample Total c./min./24hrs.	24-hour Sample Volume in ml.	Remarks
1	Jan. 21	174		*3,654		*Total activity calculated from highest spot sample count on basis of 1050 ml. of urine excreted per day.
2	22	d 160 219		*4,599		
3	Feb. 11	264		*5,544		
4	17	187		*3,927		
5	25	176		*3,696		
6	Mar. 3	186		*3,906		d Analysis on another 50ml. taken from same spot sample.
7	6		74	1,973	1335	
8	10		90	2,009	1110	
9	13		48	2,467	2570	r Recount of disc used to collect the activity from the 50ml. sample.
10	17		89	1,877	1055	
11	20		33	934	1395	
12	24		23	1,068	2315	
13	27		56	543	485	
14	31		29	740	1270	
15	Apr. 3		17	379	1130	
16	7		9	214	1220	
17	14		29	596	1015	
18	21		26	601	1145	
19	28		15	651	2115	
20	May 5		9	364	2000	
21	12		19	716	1845	
22	19		3	83	1400	
23	26		9	331	1840	

(cont'd.)

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CHART 1 (cont'd.)

Sample No.	Date 1947	Spot Sample c./min./50ml.	24-hour Sample Average c./min./50ml.	24-hour Sample Total c./min./24hrs.	24-hour Sample Volume in ml.	Remarks
24	June 2		0	0	940	Obviously erroneous
25	9	d 8 13		*273		
26	11	19		*399		
27	16	r 15 15		*315		
28	18	2		*42		
29	23	d 2 2		*42		
30	27	d 9 11		*231		

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CHART 2

URINE ACTIVITY ANALYSES
CHEMIST B

Sample No.	Date 1947	Spot Sample c./min./50ml.	24-hour Sample			Remarks
			Average c./min./50ml.	Total c./min./24hrs.	Volume in ml.	
1	Jan. 20	734		*15,414		*Total activity calculated from highest spot sample count on basis of 1050 ml. of urine excreted per day.
2	21	725		*15,225		
3	22	d 481 500		*10,500		
4	27	662		*13,902		
5	28		183	7,291	1990	
6	30	450		*9,450		d Analysis on another 50ml. taken from same spot sample.
7	31	310 d 250		*6,510		
8	Feb. 3		521	10,999	1055	
9	10		547	7,223	660	r Recount of disc used to collect the activity from the 50 ml. sample.
10	12	r 351 361		7,581		
11	17		287	8,271	1440	
12	18	r 499 520		*10,920		
13	20		291	12,290	2115	
14	24		288	8,307	1440	
15	27		186	7,643	2060	
16	Mar. 3		205	9,145	2235	
17	6		170	7,403	2175	
18	10		367	10,580	1440	
19	13		214	6,735	1575	
20	17		318	9,321	1465	
21	20		274	7,590	1385	
22	24		271	7,994	1475	

(cont'd)

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CHART 2 (cont'd.)

Sample No.	Date 1947	Spot Sample c./min./50ml.	24-hour Sample Average c./min./50ml.	24-hour Sample Total c./min./24hrs.	24-hour Sample Volume in ml.	Remarks
23	Mar. 27		116	4,869	2105	
24	31		213	5,371	1260	
25	Apr. 3		246	6,062	1230	
26	7		143	4,380	1535	
27	14		110	3,840	1740	
28	21		128	6,226	2455	
29	28		124	4,007	1620	
30	May 12		100	3,085	1540	
31	26		113	5,403	2400	
32	June 9		41	1,567	1895	
33	16		37	1,570	2130	
34	23		49	1,023	1035	
35	30		35	688	995	
36	July 7		21	627	1525	
37	14		13	323	1260	
38	21		18	470	1305	
39	28		14	311	1120	
40	Aug. 4		23	454	975	
41	11		20	255	650	
42	18		8	180	1100	
43	25		14	397	1460	
44	Sept. 8		9	197	1005	Terminated employment.

CHART 3

URINE ACTIVITY ANALYSES
CHEMIST C

Sample No.	Date 1947	Spot Sample c./min./50ml.	24-hour Sample Average c./min./50ml.	24-hour Sample Total c./min./24hrs.	24-hour Sample Volume in ml.	Remarks
1	Jan. 20	2190		*45,990		*Total activity calculated from highest spot sample count on basis of 1050 ml. of urine excreted per day.
2	21	2108		*44,268		
3	22	2590 d 2568		*54,390		
4	24	3615 d 3409		*75,915		
5	27	3157 r 2882		*66,297		d Analysis on another 50ml. taken from same spot sample.
6	29	3118 d 2909		*65,478		
7	30	1742		*36,582		
8	31	3204 d 2408		*67,284		r Recount of disc used to collect the activity from the 50 ml. sample.
9	Feb. 3		1878	34,172	910	
10	4	3009 r 2979		*63,189		
11	6	2349 d 2236		*49,329		
12	10		1379	37,301	1383	
13	11	1616		*33,936		
14	12	1961 r 1922		*41,181		
15	17		1126	33,339	1480	
16	18	1948 r 1944		*40,908		
17	20		1606	44,161	1375	
18	24		1091	31,303	1435	

(cont'd.)

CHART 3 (cont'd.)

Sample No.	Date 1947	Spot Sample c./min./50ml.	24-hour Sample Average c./min./50ml.	24-hour Sample Total c./min./24hrs.	24-hour Sample Volume in ml.	Remarks
19	Feb. 27		809	21,683	1340	
20	Mar. 3		906	26,567	1410	
21	6		1036	20,400	985	
22	10		891	18,265	1025	
23	13		1134	21,666	955	
24	17		779	28,688	1840	
25	24		347	11,660	1680	
26	27		414	13,538	1635	
27	31		472	15,608	1655	
28	Apr. 3		484	26,937	2780	
29	7		308	9,398	1525	
30	14		240	4,875	1015	
31	21		350	10,390	1485	
32	28		564	9,356	830	
33	May 5		244	7,359	1505	
34	12		320	6,120	960	
35	19		512	9,215	900	
36	26		359	6,828	950	
37	June 2		238	4,690	985	
38	9		250	4,630	925	
39	16		209	4,266	1020	
40	23		113	3,422	1510	
41	30		237	3,122	660	
42	July 7		112	2,878	1285	
43	14		70	1,786	1280	

(cont'd.)

CHART 3 (cont'd.)

Sample No.	Date 1947	Spot Sample c./min./50ml.	24-hour Sample Average c./min./50ml.	24-hour Sample Total c./min./24hrs.	24-hour Sample Volume in ml.	Remarks
44	July 21		92	1,672	1280	
45	28		79	1,454	915	
46	Aug. 4		78	1,023	660	
47	11		55	787	710	Terminated employment Aug. 15, 1947.
48	Sept. 12	18		*378		
49	19	25		*525		
50	25	20		*420		
51	Oct. 2	11		*231		
52	16	13		*273		
53	23	6		*126		
54	30	2		*42		

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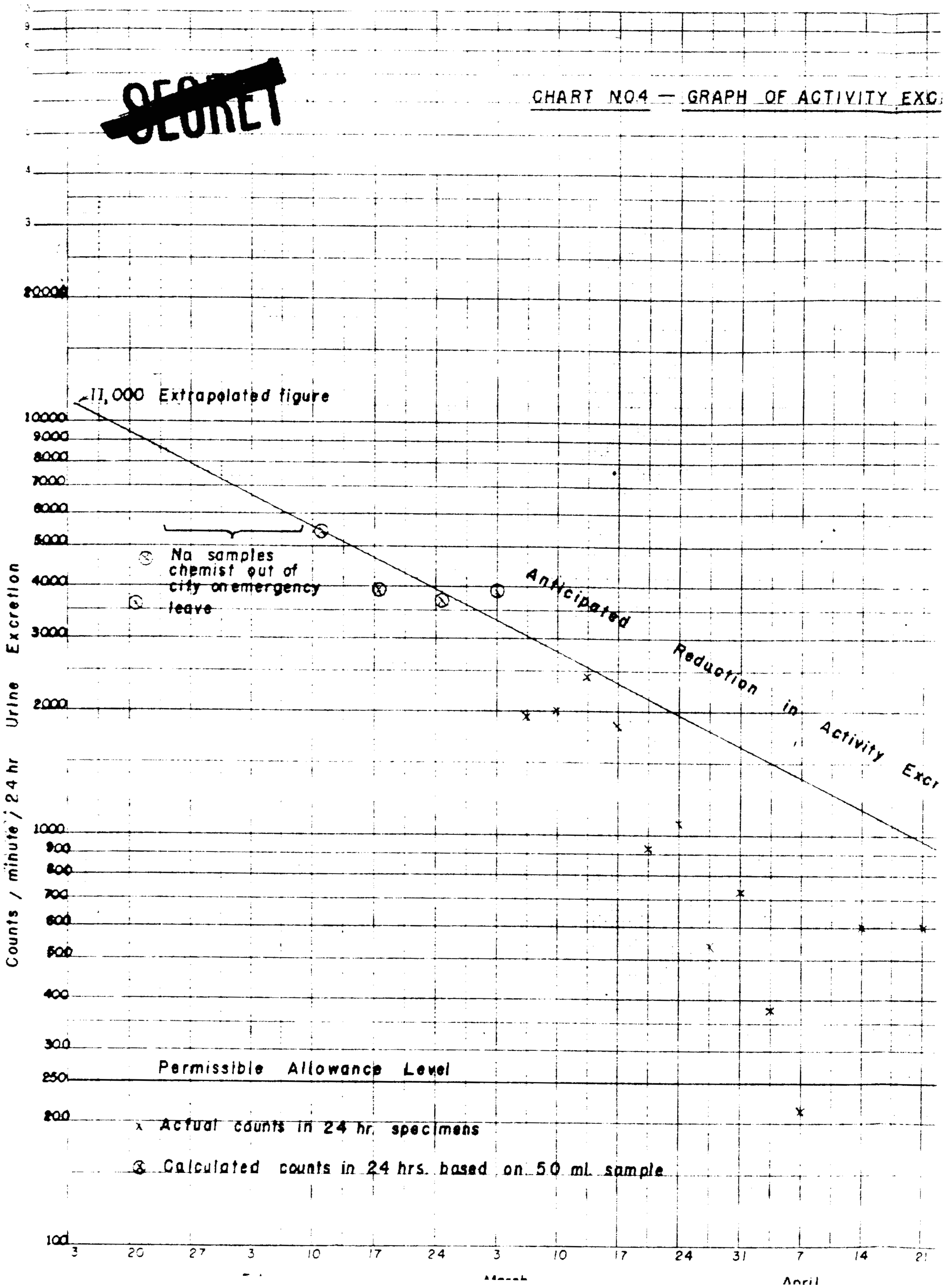

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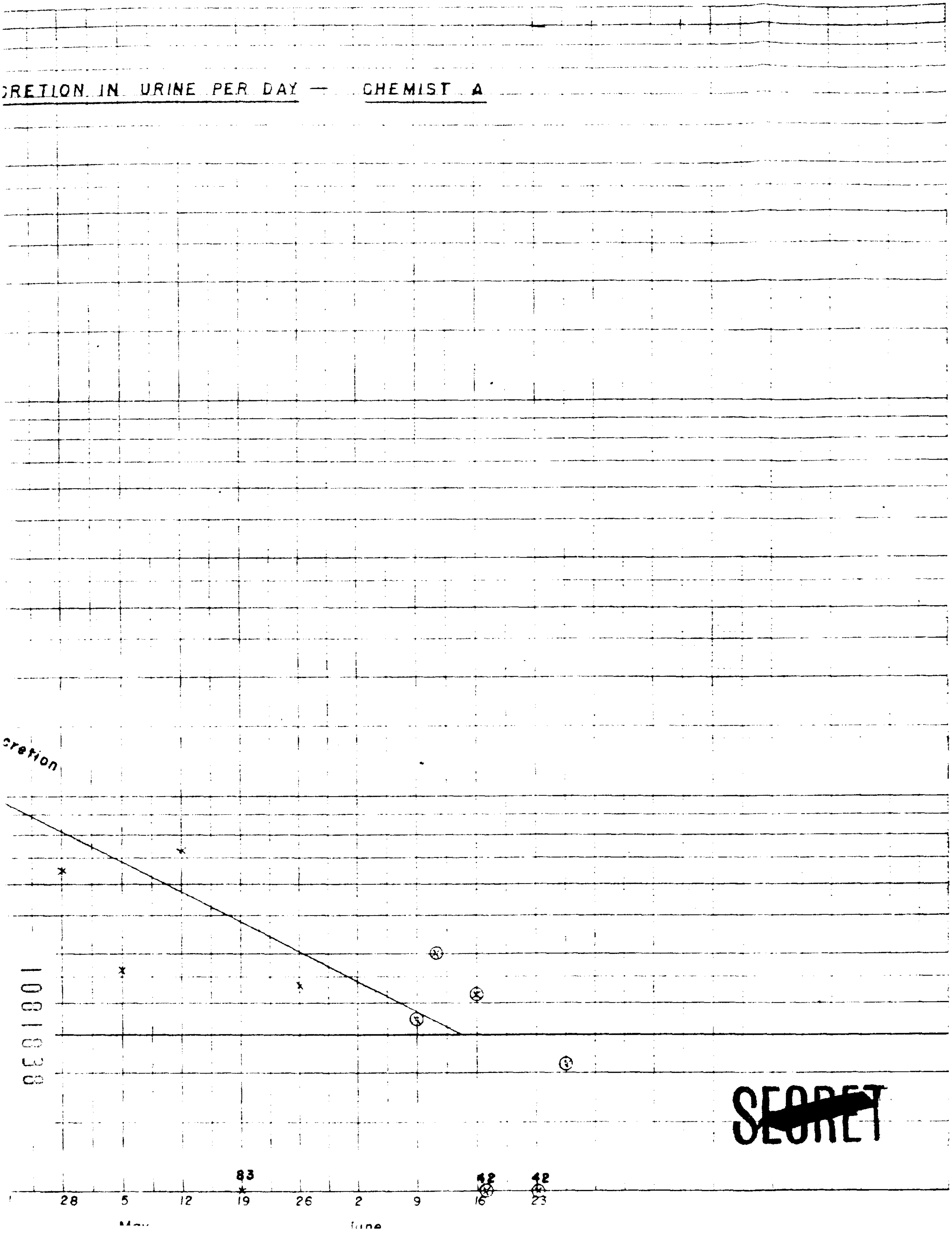
CRETION IN URINE PER DAY — CHEMIST A
cretion
83
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28
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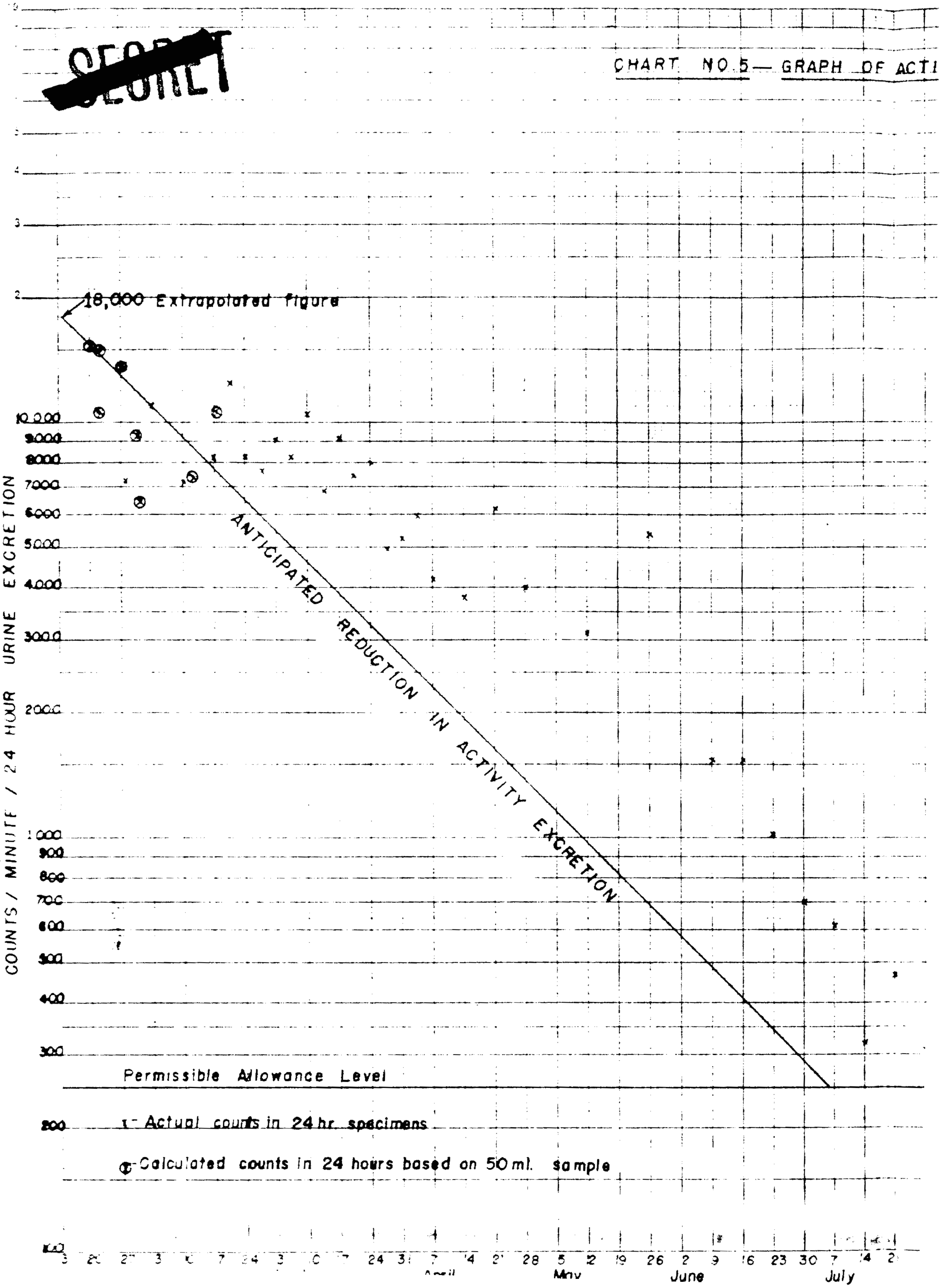
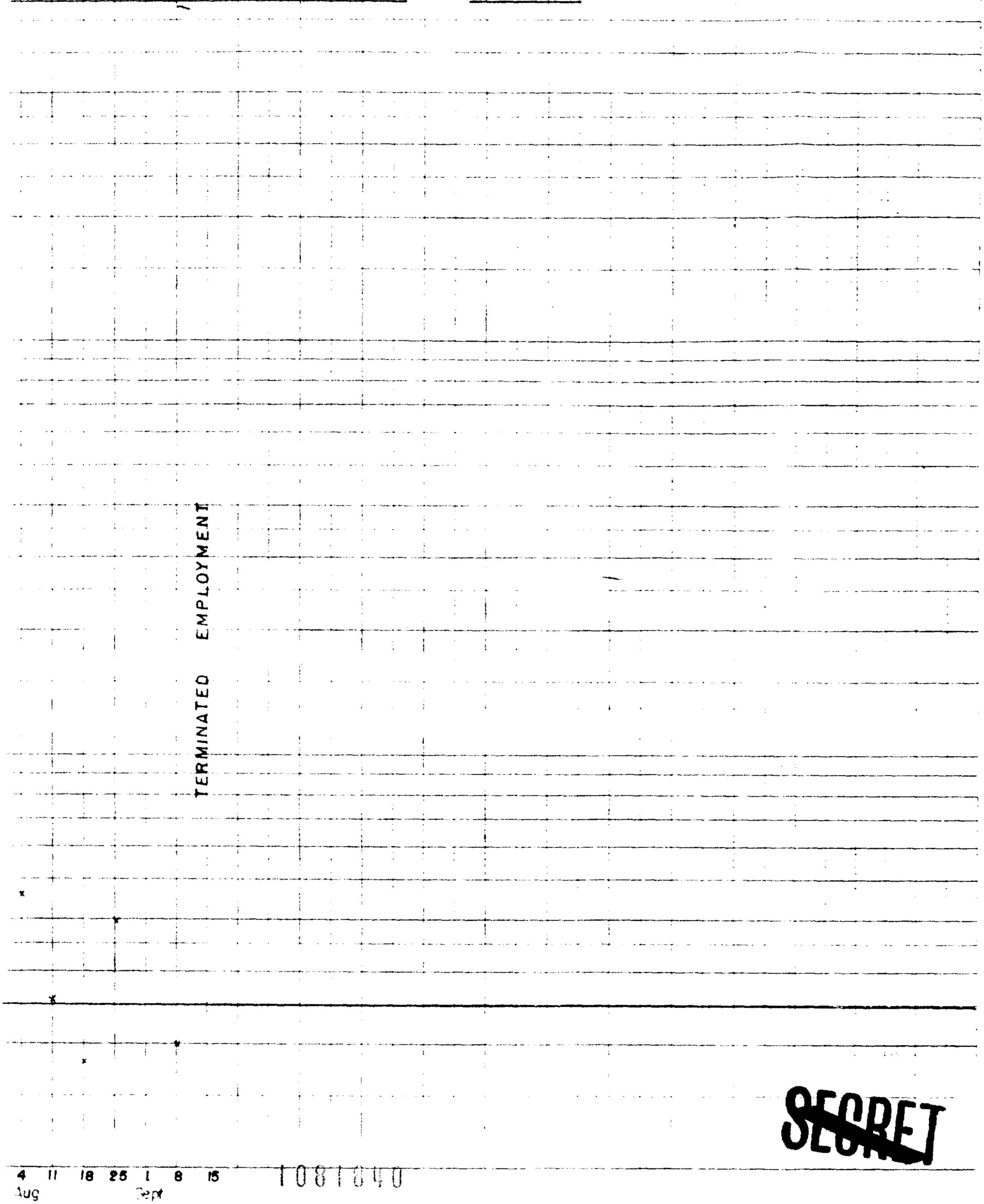
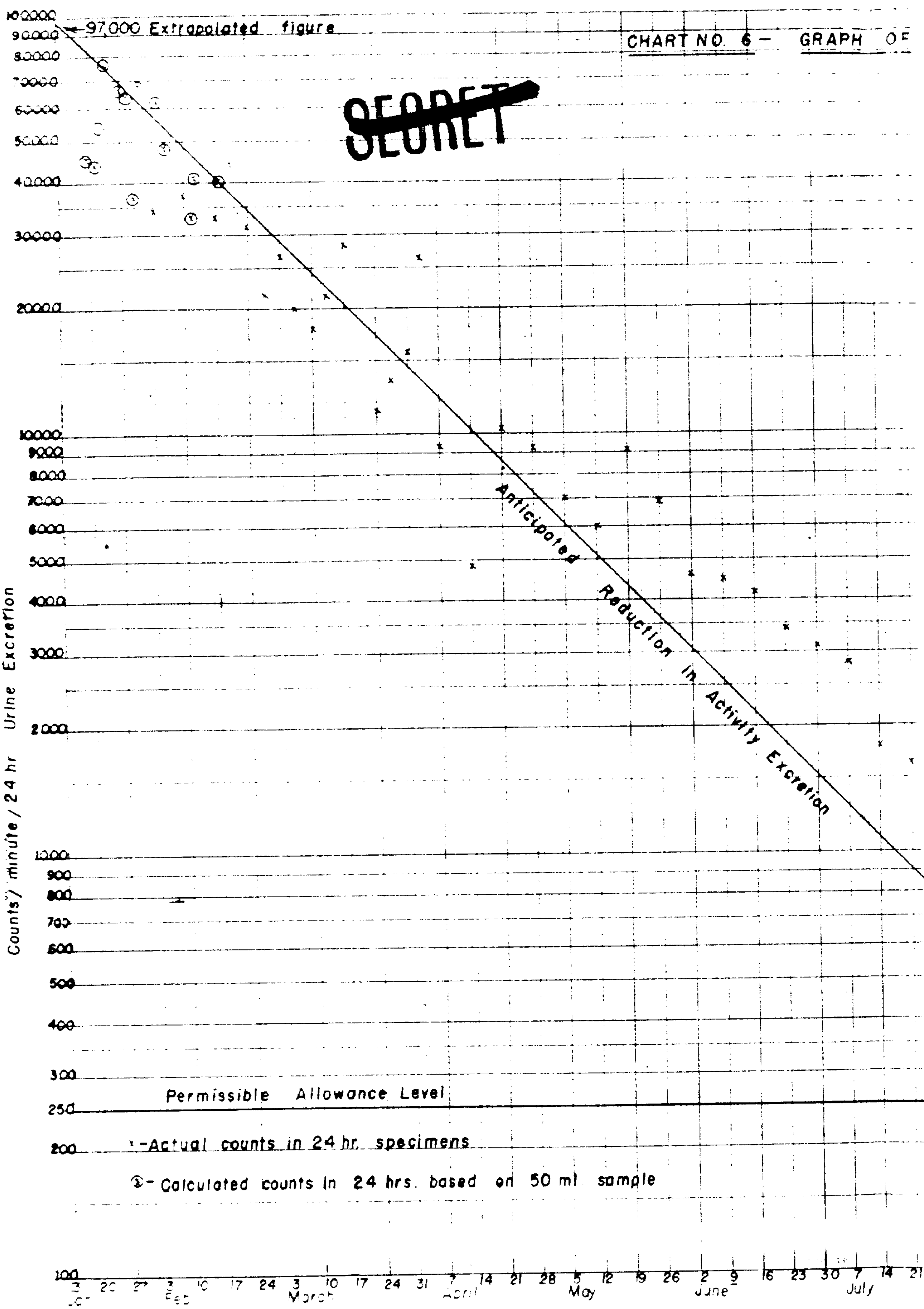


CHART NO.5 — GRAPH OF ACTI
18,000 Extrapolated figure
ANTICIPATED REDUCTION IN ACTIVITY EXCRETION
Permissible Allowance Level
x - Actual counts in 24 hr. specimens
⊗ - Calculated counts in 24 hours based on 50 ml. sample
COUNTS / MINUTE / 24 HOUR URINE EXCRETION
10,000
9000
8000
7000
6000
5000
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
May
June
July

VITY EXCRETION IN URINE PER DAY — CHEMIST B





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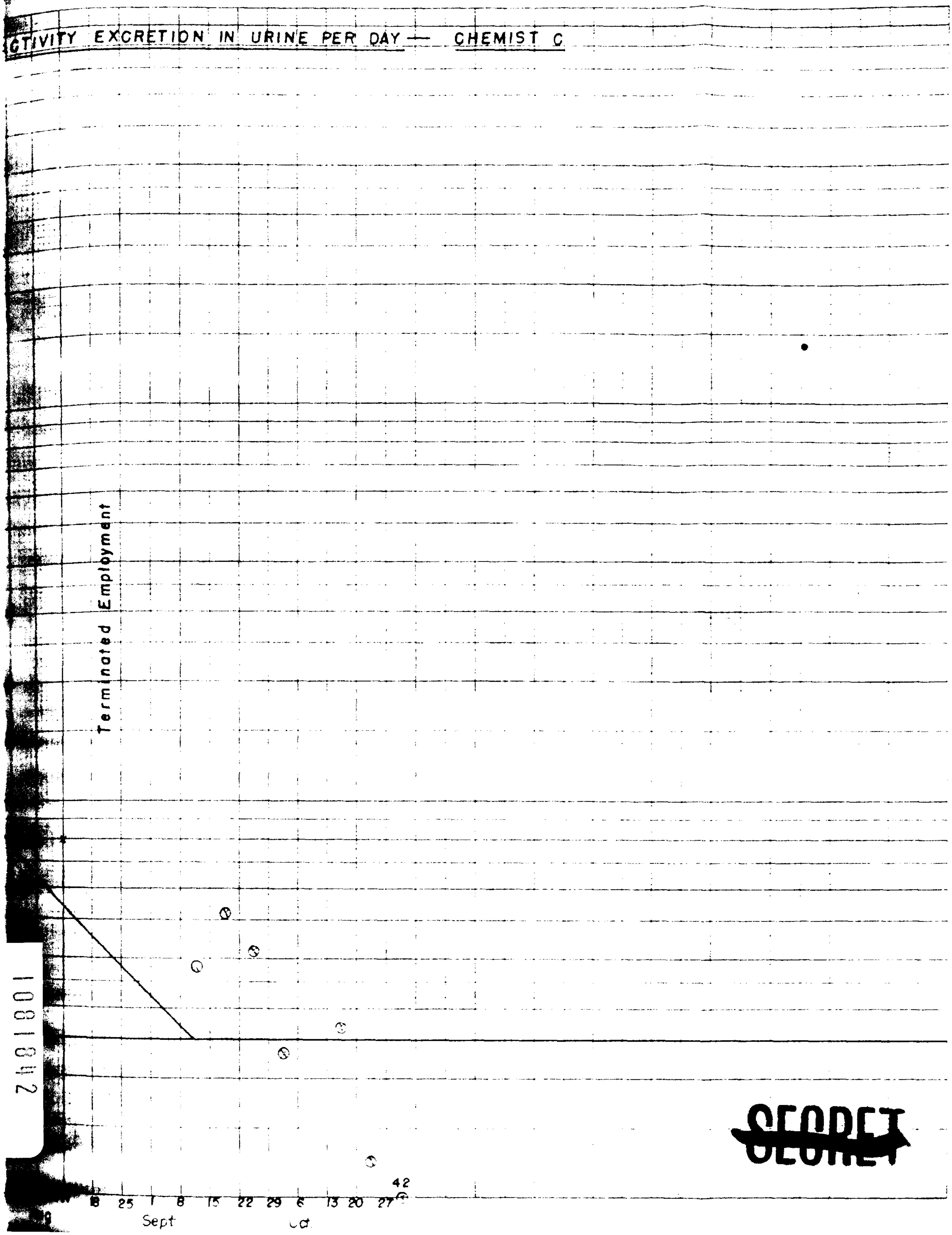

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CHART 7

ROUTINE URINALYSES
CHEMISTS A, B, & C

No. of Sample	Date of Sample	SG	pH	Albumin	Sugar	RBC	WBC	Casts
				Chemist A				
	1947							
1	Mar. 12	1.016	5.5	Neg.	Neg.	0	0	0
2	June 6	1.022	7.0	Neg.	Neg.	0	0	0
				Chemist B				
	1947							
1	Feb. 20	1.028	7.5	Neg.	Neg.	0	0	0
2	Mar. 25	1.020	5.5	Neg.	Neg.	0	0	0
3	Apr. 15	1.028	5.5	Neg.	Neg.	0	0	0
4	May 28	1.022	5.5	Neg.	Neg.	0	0	0
5	June 24	1.030	6.0	Neg.	Neg.	0	0	0
6	July 10	1.012	5.5	Neg.	Neg.	0	0	0
7	Sept. 11	1.022	6.0	1 +	Neg.	0	0	0
				Chemist C				
	1947							
1	Feb. 19	1.034	5.5	Neg.	Neg.	0	0	0
2	Mar. 4	1.030	6.0	Neg.	Neg.	0	0	0
3	Mar. 26	1.014	5.5	Neg.	Neg.	0	0	0
4	Apr. 15	1.026	5.5	Neg.	Neg.	0	Occ'l.	0
5	May 20	1.024	5.5	Neg.	Neg.	0	Occ'l.	0
6	June 26	QNS	6.0	Neg.	Neg.	0	Occ'l.	0

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CHART 5

BLOOD COUNTS
CHEMIST A

Sample No.	Date	Hemoglobin GM/100cc.	Hemoglobin %	RBC 10^6	WBC	differential: Polys.	St.	Eosin.	Bas.	Lymph	Mono	Remarks
	1946											
1*	Apr. 18	17.6	104	4.85	5200	74				24	2	*Blood counts taken prior to time of acute exposure.
2*	July 19	15.5	90	4.82	8100	68				28	4	
3*	Oct. 15	17.2	102	5.23	9600	75				20	5	
	1947											
4	Feb. 11	15.2	88	5.09	8950	77		1	1	20	1	
5	Feb. 18	16.7	98	5.23	6800	74		4	2	20		
6	Feb. 24	16.9	99	4.38	7000	62	1	4		33		
7	Mar. 4	16.0	95	4.70	7500	60		2		37	1	
8	Mar. 12	16.0	95	4.81	6950	70	1	3	1	23	2	
9	Mar. 18	16.7	98	4.32	9200	67		1		32		
10	Apr. 2	17.0	100	4.36	9000	65	1	3		31		
11	Apr. 17	17.0	100	4.52	9200	60	3	1		35	1	
12	Apr. 29	16.0	95	4.60	7000	59	3	4		34		
13	May 16	16.3	96	5.00	8450	57	2	1	1	37	2	
14	June 6	15.9	93	4.28	7250	61	3			35	1	
15	June 17	16.0	94	4.44	5250	60		2		38		
16	July 1	17.0	100	4.71	6300	70	1	2		25	2	
17	Oct. 14	18.0	106	4.22	5300	57		2		41		

SECRET

CHART 9

BLOOD COUNTS
CHEMIST B

Sample No.	Date	Hemoglobin GM/100cc.	Hemoglobin %	RBC 10^6	WBC	differential: Polys.	St.	Eosin.	Bas.	Lymp	Mono	Remarks
1*	1946 Oct. 1	16.0	94	4.83	8500	78		2		17	3	*Only blood count available prior to acute exposure
2	1947 Feb. 7	16.5	96	4.99	6000	57		5		33	5	
3	Feb. 11	18.0	106	5.03	6950	60		5	2	27	6	
4	Feb. 18	18.0	106	4.81	9000	79		3		16	2	
5	Feb. 26	15.3	89	4.81	9100	65		2		33		
6	Mar. 4	17.0	100	4.91	6850 6500	58				42		2nd technician rpts. WBC of 6550, 6500.
7	Mar. 18	17.0	100	4.77	5950 6150	61	5	1		33		2nd technician rpts. WBC of 5650, 5000.
8	Mar. 25	16.3	95	5.18	6100 6100	48	3	3		45	1	
9	Apr. 1	16.0	94	4.96	4400 4600	52	2	2		44		
10	Apr. 2				5800 5900	71		1		27	1	2nd technician rpts. WBC of 5400, 5400.
11	Apr. 15	17.8	104	4.85	5100 6350	65		3		29	3	
12	Apr. 29	16.5	96	5.30	6500	67	3			29	3	
13	May 13	17.0	100	5.06	4450 4400	49	2	2		47		
14	June 6	17.0	100	4.56	5850	57		3		38	2	
15	June 24	15.8	92	4.79	5350	50	4	3		43		
16	July 9	15.5	90	5.00	4900	54		4		42		
17	July 22	15.8	92	4.50	4450	52		3	1	44		
18	Aug. 7	15.0	88	4.44	5200	65	2	3		30		
19	Aug. 21	16.0	94	4.63	4800	52		8		39	1	
20	Sept. 11	15.9	93	4.37	5200	57	1	6		36		

SECRET

CHART 10

BLOOD COUNTS
CHEMIST C

Sample No.	Date	Hemoglobin GM/100cc.	Hemoglobin %	RBC 10^6	WBC	differential Polys.	St.	Eosin.	Bas.	Lymp	Mono	Remarks
1*	1945 Nov. 28	17.3	102	5.36	7500	66		1		30	3	*All blood counts taken prior to time of acute exposure.
2*	1946 Jan. 17	16.7	98	5.34	8650	61	2			33	4	
3*	Feb. 8	17.0	100	4.85	7700	58		2		38	2	
4*	Mar. 20	16.7	98	4.85	5400	60		1		38	1	
5*	June 11	16.0	94	5.94	8400	46		2		49	2	
6*	July 19	15.0	88	4.96	9300	59		4	1	32	4	
7*	Oct. 15	15.0	88	5.16	9150	62		2		33	3	
8	1947 Jan. 29	17.5	104	5.21	7200	77		3		20		
9	Feb. 7	17.0	100	5.06	6400	69		1		29	1	
10	Feb. 11	16.5	98	5.59	6800	71		1		25	3	
11	Feb. 18	17.0	100	5.17	6750	65		4		27	4	
12	Feb. 25	17.5	102	5.00	6000	58	2		1	34	1	
13	Mar. 4	15.5	92	5.29	5750 5800	59	2	2		36	1	2nd technician rpts. WBC of 6250, 6100.
14	Mar. 11	16.1	94	5.44	7950 5300	60	3	1		32	3	2nd technician rpts. WBC of 6850, 6000.
15	Mar. 18	15.2	89	5.06	7000 6150	57	5	4		34		2nd technician rpts. WBC of 7000, 6300.
16	Apr. 1	15.0	88	5.6	5650 5650	57	5	3		34	1	
17	Apr. 15	16.0	94	5.65	5000 5050	68		2		27	3	
18	Apr. 29	16.5	98	4.05	6800	60	1	3		36		
19	May 13	15.0	88	4.90	6050	50	1			49		

(cont'd.)

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CHART 10 (cont'd.)

Sample No.	Date	Hemoglobin GM/100cc	Hemoglobin %	RBC 10^6	WBC	Polys.	St.	Eosin.	Bas.	Lymp	Mono	Remarks
20	1947 May 27	15.3	90	4.96	7150	61		1		38		
21	June 10	14.4	84	4.61	5700	62		2		36		
22	June 24	15.0	88	4.65	6000	64				36		
23	July 9			4.69	6800	65		2		33		
24	July 23	16.0	94	4.47	6950	69	5	1		25		
25	Aug. 5	16.0	94	4.46	6200	50	3	6		41		
26	Sept.17			4.74	5900	55		5		33	7	
27	Oct. 16			4.27	5000	59		1		39	1	

DHN/cm

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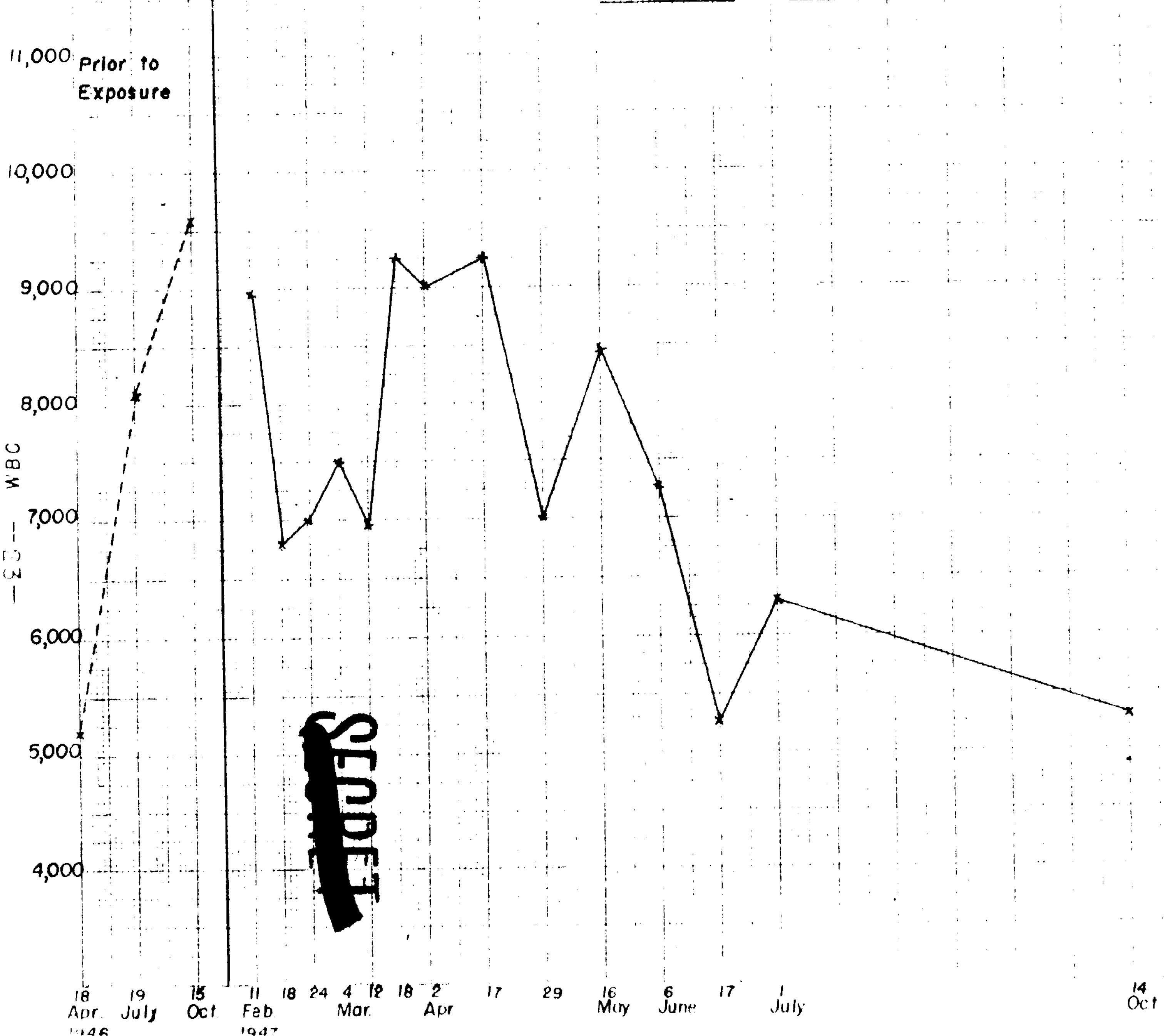
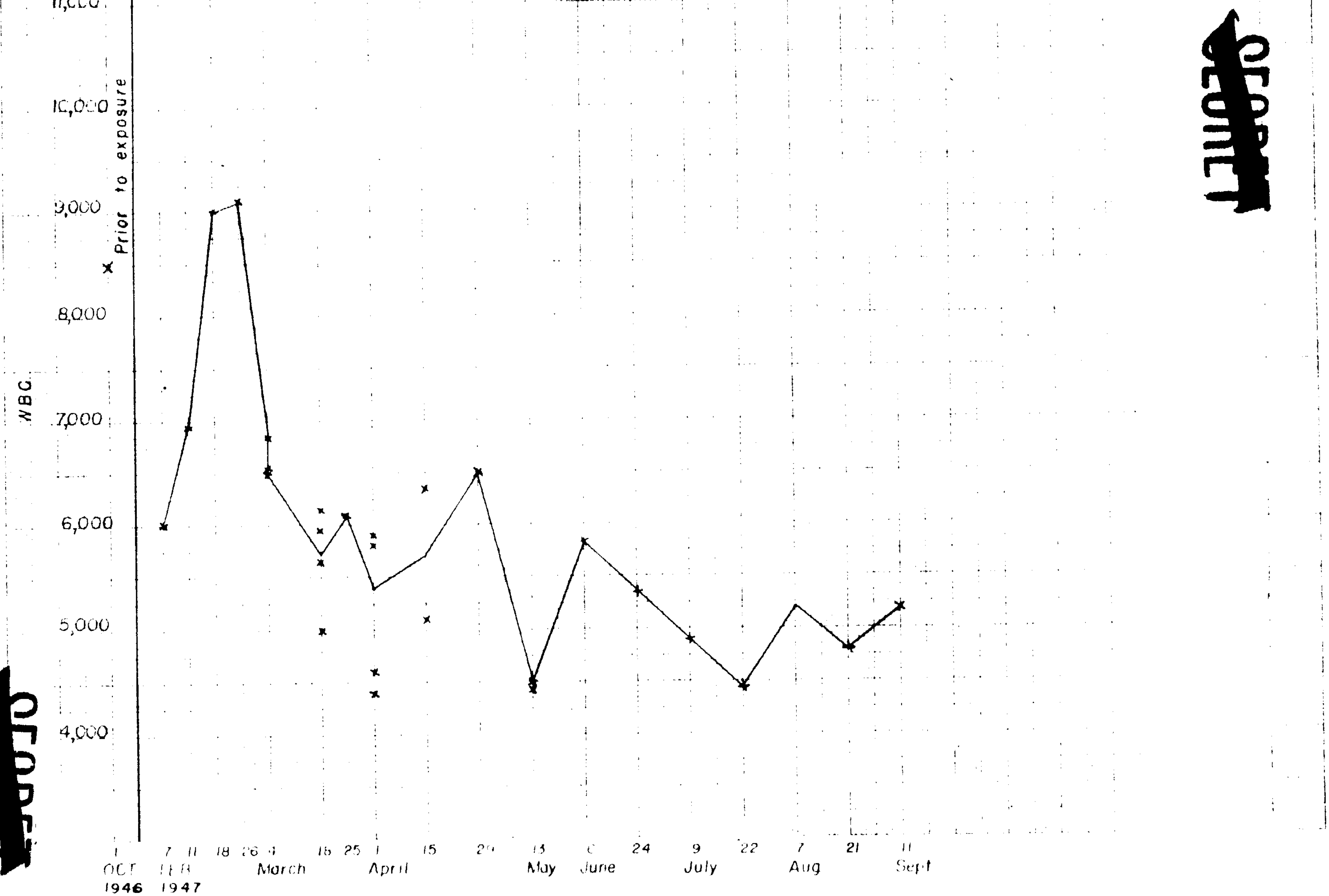
CHART NO. 11 - GRAPH OF WBC COUNTS - CHEMIST A



SECRET

SECRET

CHART NO 12 - GRAPH OF WBC COUNTS - CHEMIST B



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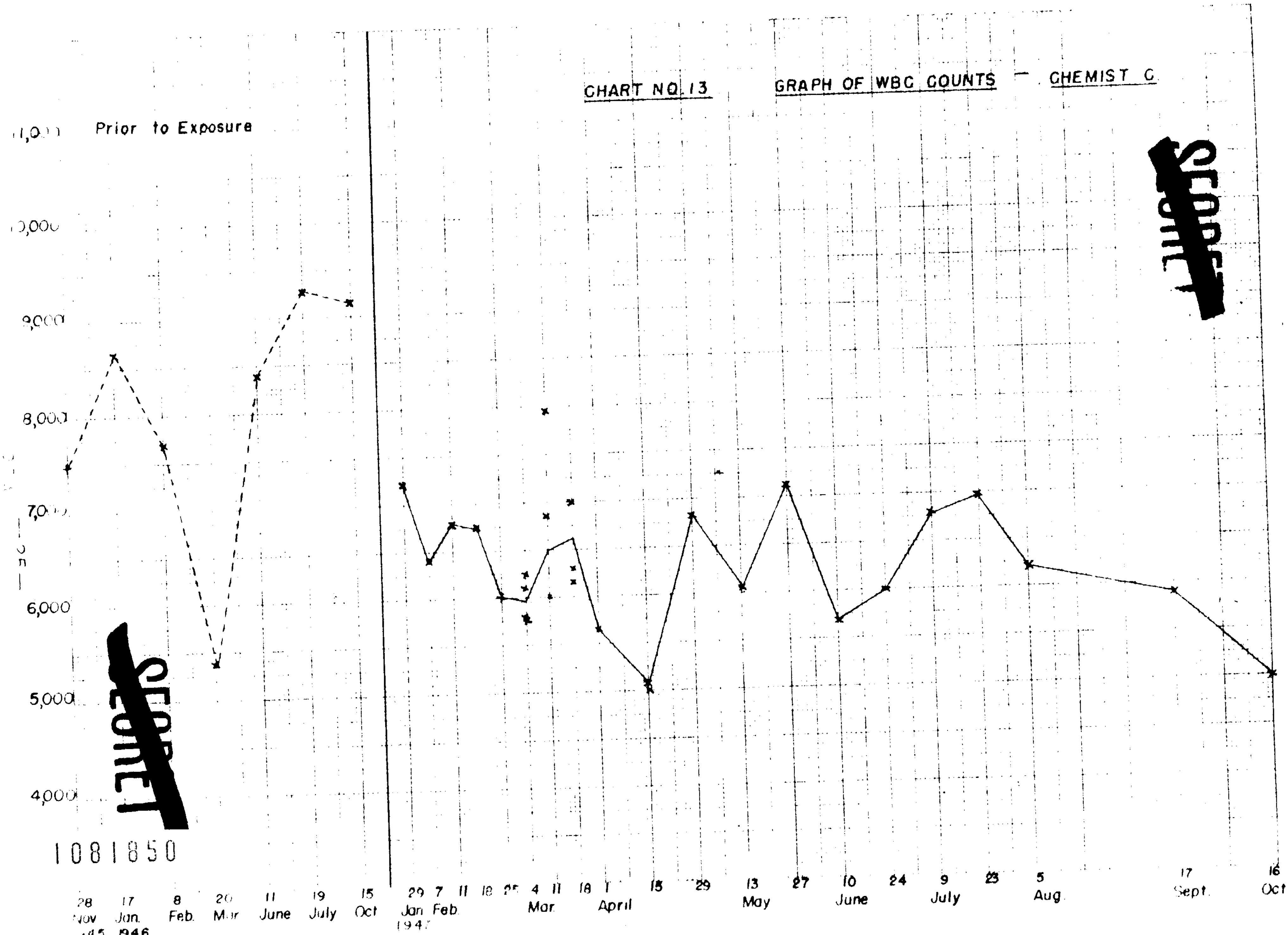
CHART NO. 13
GRAPH OF WBC COUNTS — CHEMIST C
Prior to Exposure
9,000
8,000
6,000
5,000
4,000
28 Nov
17 Jan. 1946
8 Feb.
20 Mar
11 June
19 July
15 Oct
29 Jan 1947
7 Feb.
11
4 Mar.
11
18
1 April
15
29
13 May
27
10 June
24
9 July
23
5 Aug.
17 Sept.
16 Oct
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