

FINAL REPORT  
ON A STUDY OF  
DETERGENTS IN RELATION TO SEWAGE  
AND SEWAGE TREATMENT  
FOR THE SOAP AND DETERGENT ASSOCIATION

BY

THE NATIONAL SANITATION FOUNDATION

ANN ARBOR, MICHIGAN

April 26, 1968

# FINAL REPORT

ON

## A STUDY OF DETERGENTS IN RELATION TO SEWAGE AND SEWAGE TREATMENT

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### I. GENERAL

This is the final report on a study of the concentration and reduction of surface active agents in package sewage treatment plants and the "die-away" characteristics of these agents in relation to time of contact with domestic sewage. In October of 1965 the Soap and Detergent Association made arrangements with the National Sanitation Foundation to begin such a study and three progress reports on the findings of the study have been submitted to the Association prior to this final report.

The first report contained data on the package plant operations at the National Sanitation Foundation Research Site from October 1955 through February 1966. The second report was submitted on September 1966 with subsequent data. Continued data on the sewage characteristics and Methylene Blue Active Substance (MBAS) values in package plants operations obtained between September 1966 and July 1967 was presented in the Third Progress Report. In addition to the package plant data, MBAS data for the Ann Arbor Waste Water Plant, which is a conventional activated sludge plant operated by this municipality, was included in all the reports except during a short period while new additions to the plant were being constructed. The sewage being treated by the package plants and the Ann Arbor plant has the same characteristics, since the source of sewage for both is from the City of Ann Arbor. This provides for a comparison of removals between several types of treatment facilities.

This final report covers the period from July 1967 until January 1968 and contains more information on contact stabilization plants than in the previous reports. It also includes information on the removal of MBAS on package plants of the extended aeration type while they are being evaluated according to the criteria developed by the Foundation for plants of this type.

### II. THE ANN ARBOR WASTE WATER TREATMENT PLANT

This plant, which was completely described in the First Progress Report and subsequently referred to in the succeeding reports, has been enlarged and modified so that the "step aeration" process could be substituted for the conventional activated sludge process if desired. The step aeration process was utilized during the last four months of the period that this report covers. The monthly ranges and mean values for MBAS content in the influent to the plant and the effluent from the same plant are shown in Table I for a fourteen month period. It should be noted that the influent to the plant showed monthly mean values of MBAS that decreased from 8.1 mg/liter in November 1966 to 4.2 mg/liter in June 1967. The downward trend of MBAS content in the Ann Arbor sewage then reversed and increased in August and September. In October 1967 it again dropped to 5.5 mg/liter and stayed almost constant in concentration through to January 1968.

TABLE I DETERMINATIONS OF METHYLENE BLUE ACTIVE SUBSTANCES

Daily Composite Influent and Effluent Samples from the Ann Arbor, Michigan Waste Water Treatment Plant  
 Period November 17, 1966 Through January 11, 1968

Month or Period	No. of Daily Influent Samples Analyzed each mo.	Range of MBAS Values Influent mg/l	Mean MBAS Influent Values	No. of Daily Effluent Samples Analyzed each mo.	Range of MBAS Values Effluent mg/l	Mean MBAS Effluent mg/l	% Reduction (Averages) MBAS
Nov. 1966	14	5.3 - 10.3	8.1	14	0.8 - 2.0	1.6	80.0%
Dec. 1966	27	4.0 - 10.0	6.4	27	1.3 - 3.3	1.9	70.3%
Jan. 1967	28	3.9 - 10.5	6.8	29	1.3 - 5.0	3.2	53.0%
Feb. 1967	28	4.0 - 8.8	5.5	28	1.3 - 5.3	2.3	58.2%
Mar. 1967	28	3.0 - 7.5	5.2	28	1.0 - 2.8	1.8	65.6%
Apr. 1967	29	2.5 - 8.3	5.4	29	1.0 - 3.0	1.8	66.7%
May 1967	31	2.0 - 8.0	5.1	31	1.1 - 4.0	2.1	59.3%
June 1967	29	1.3 - 6.3	4.2	29	0.4 - 3.5	2.0	52.5%
July 1967	30	1.5 - 7.4	4.4	30	0.5 - 2.0	1.1	75.0%
Aug. 1967	26	3.0 - 7.3	5.2	26	0.2 - 2.3	0.8	84.6%
Sept. 1967	29	3.1 - 8.8	8.7	29	0.3 - 4.0	1.6	81.5%
Oct. 1967	31	4.0 - 7.3	5.5	31	0.5 - 3.5	1.7	69.1%
Nov. 1967	22	3.8 - 6.3	5.1	22	0.8 - 3.3	1.5	70.6%
Dec. 1967	17	3.5 - 7.0	5.2	17	0.6 - 1.8	1.2	76.8%
Jan. 1968	6	4.3 - 6.3	5.4	6	1.0 - 1.9	1.5	72.2%
Complete Period	375	1.3 - 10.5	5.7	376	0.2 - 5.3	1.8	68.3%

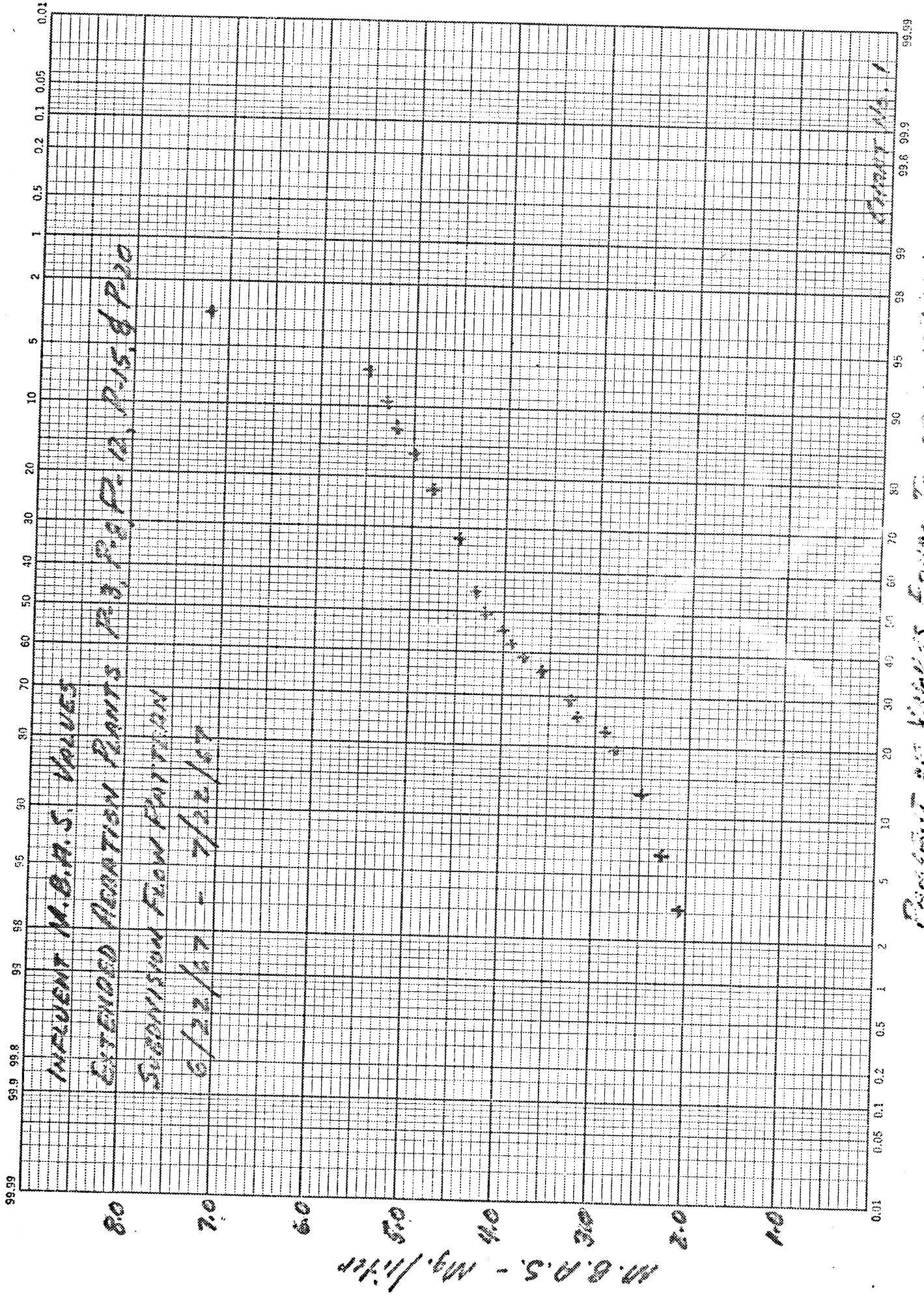
The removals of MBAS through the Ann Arbor plant were greatest during the months of highest concentration in the influent which would normally be expected. The percentage reduction as shown by the monthly averages ranged from 52.5% to 84.6% during the fourteen month period with the overall average on 375 determinations averaging 68.3%.

In the last progress report it was mentioned that the sewage that the Ann Arbor Waste Water Treatment Plant and the National Sanitation Foundation Research Site receive from the City of Ann Arbor is domestic in character. During late August and in September both the National Sanitation Foundation Research Site Package Sewage Treatment Plants and the Ann Arbor Waste Water Treatment Plant were troubled with the formation of a heavy dark foam or scum formation on the surface of the aeration compartments. A reduction in the removal efficiencies for both suspended solids and biochemical oxygen demand in the package plants occurred at the same time. These facts point to a change in characteristics of the normal domestic sewage, which was assumed to be the result of some new wastes of a different characteristic being discharged to the Ann Arbor system. Further discussion of this problem will be done in the section on package plants.

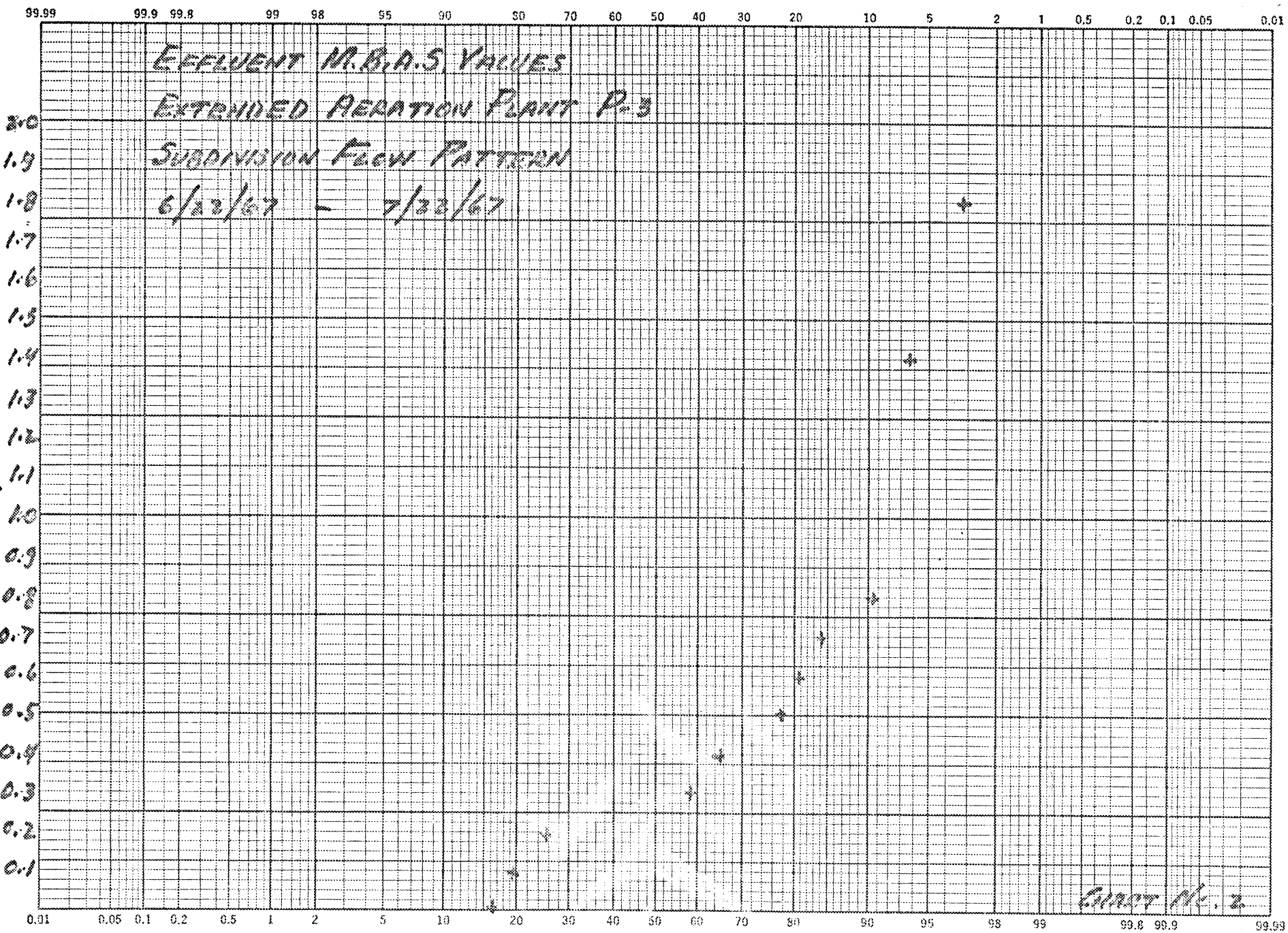
### III. PACKAGE SEWAGE TREATMENT PLANTS

The National Sanitation Foundation at the conclusion of the criteria development project on extended aeration plants proceeded to evaluate the performance of these plants at its research site. This was done in order to provide certified data on the performance of these plants under the method of evaluation prescribed in the criteria set forth in the Criteria Development Project Report. Eighteen probability plots of the MBAS values in the influent and effluent of these plants are included in this report for demonstrating MBAS removals, although the plants are not identified except by symbol. The data is available for both the subdivision and school flow patterns. In either flow pattern the removals of MBAS demonstrated by these plants were excellent since in all cases they averaged above ninety percent. (Charts 1 through 18 show the MBAS values for both influent and effluent from these plants).

The previous report contained operating data for two contact stabilization plants (C-1 and C-2) that were operated under steady state flow. The operation of the same two plants have continued to be studied during the last part of 1967. Sixteen probability plots (Charts 19 through 26) are appended to this report which indicate the influent and effluent MBAS values, Suspended Solids, Biochemical Oxygen Demand, and Chemical Oxygen Demand for one contact stabilization plant that has been operated both under the subdivision flow pattern and the steady state flow pattern. During the period that this plant (C-1) was being operated on the subdivision flow pattern it did not function with the same efficiency that it had previous to this time. From the greater extreme and mean values in the influent of MBAS and Chemical Oxygen Demand it would appear that incoming sewage contained wastes that were more difficult to treat during this period. The fact that all plants on the research site were affected by the development of a heavy scum on the surface of the aeration tanks at this time indicated that an unidentified substance or substances were present that were not normally there. Grease extractions were made of the scum



Percent air bubbles versus M.B.S. - Mg./liter



M.B.A.S. - Mg/liter

Percent of Values Equal to or Less Than

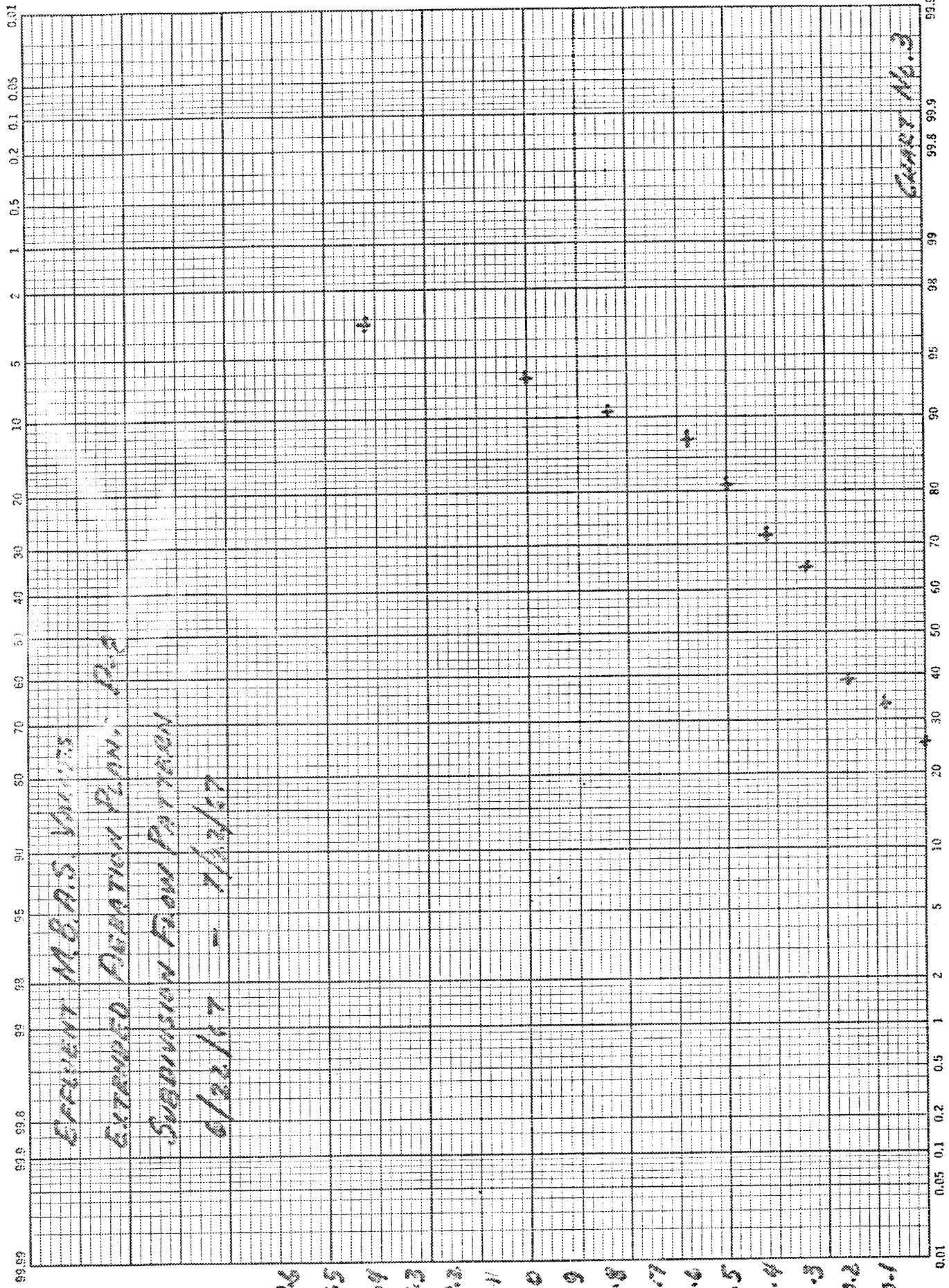
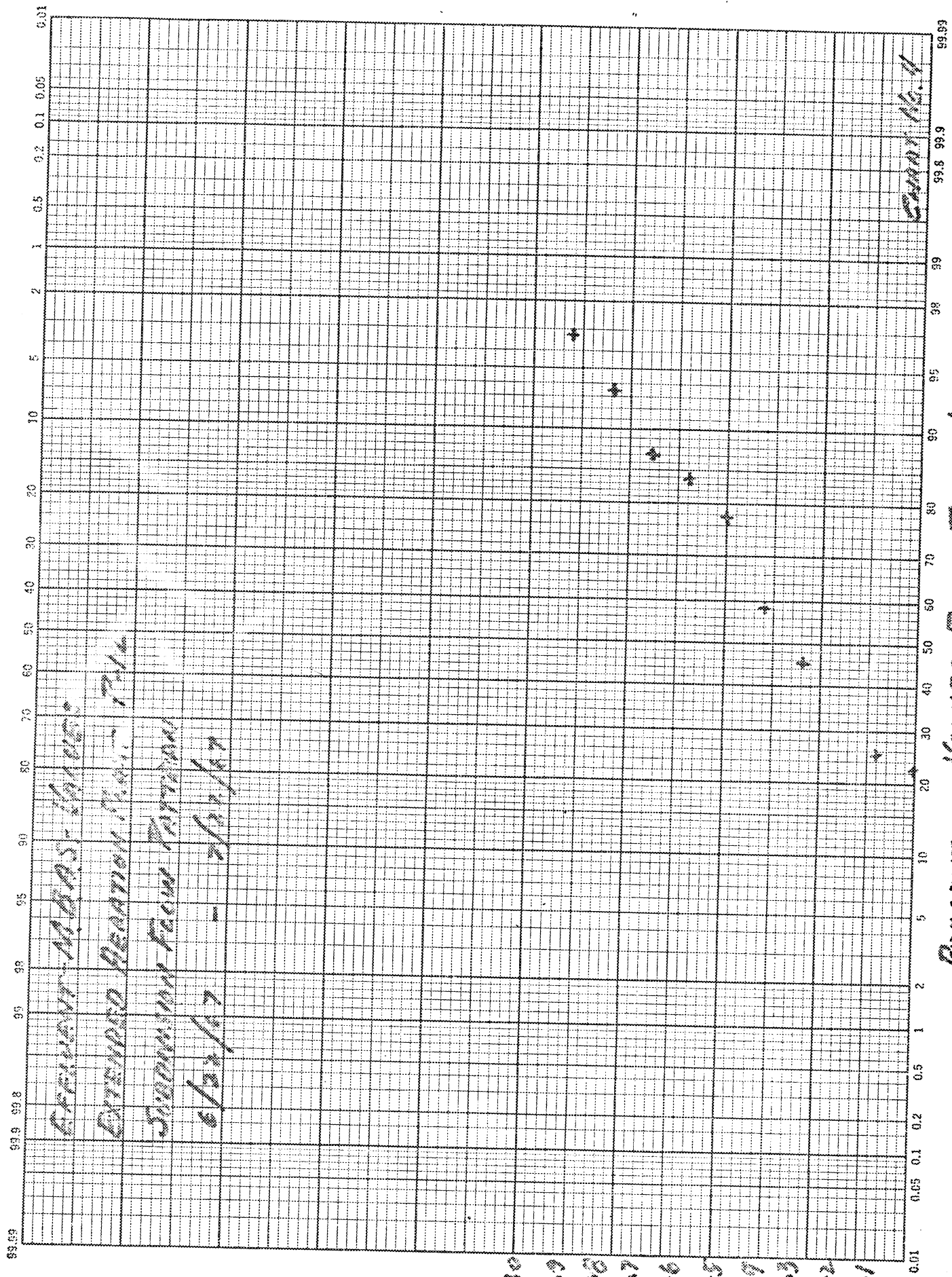


CHART No. 3

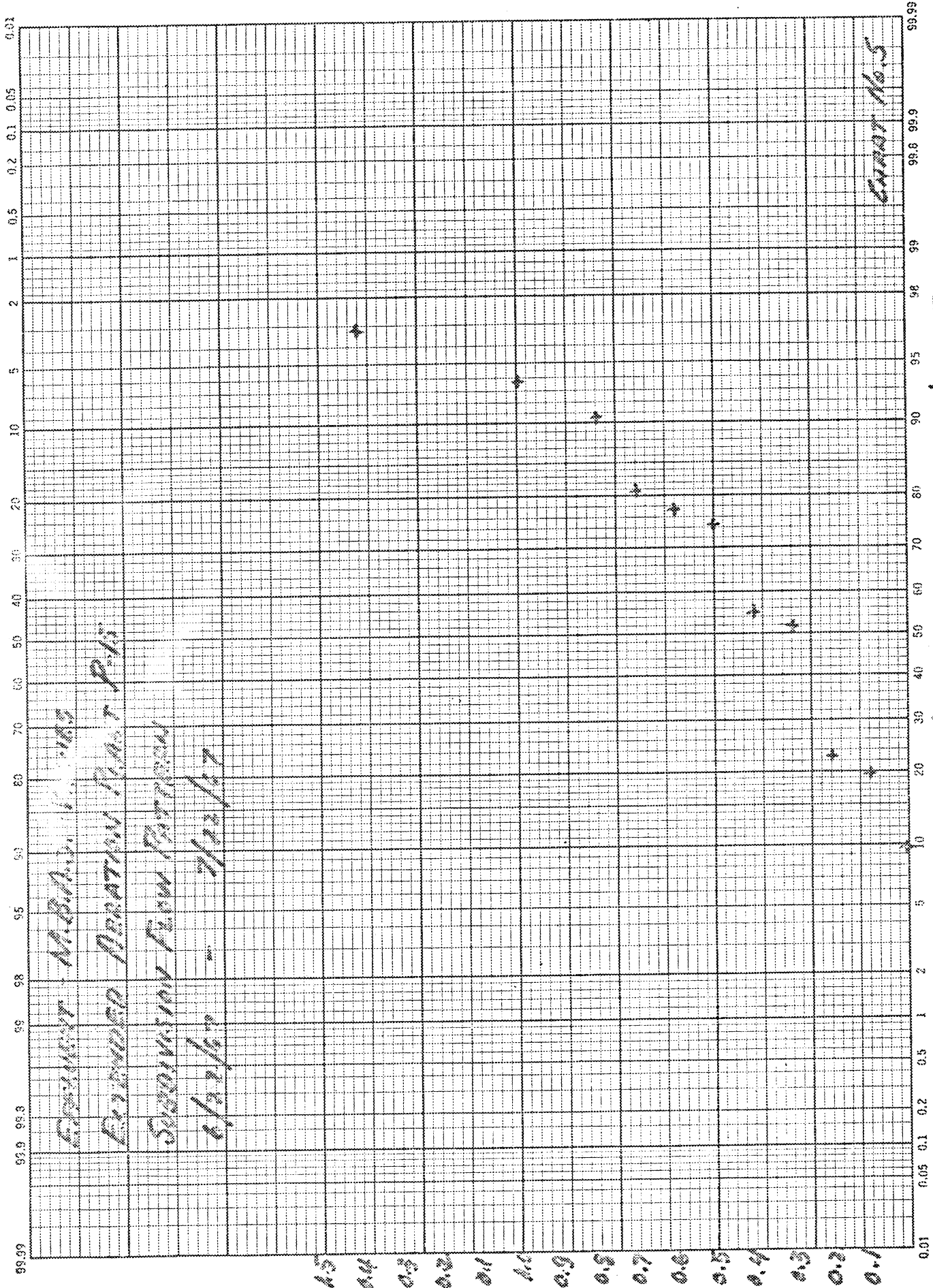
PERCENT OF VALUES FAILING TO BE LESS THAN



Frequency as a function of time

10  
 20  
 30  
 40  
 50  
 60  
 70  
 80  
 90  
 100





EXACT No. 5  
 PERCENT OF VALUES EQUAL TO OR LESS THAN  
 EXACT No. 5

17. THE PROBABILITY 46 8000  
 R. W. L. X 90 DIVISIONS MADE IN U.S.A.  
 FEDERAL ESSER CO.

PERCENT OF VALUES EQUAL TO OR LESS THAN

EXACT No. 5

99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01

EFFLUENT - M.B.A.S. - VALLEY  
 EXTENDED REACTION PLANT P-1  
 SUBDIVISION FLOW PATTERN  
 6/22/67 - 7/14/67

M.B.A.S. - Mg/liter  
 1.0  
 0.9  
 0.8  
 0.7  
 0.6  
 0.5  
 0.4  
 0.3  
 0.2  
 0.1

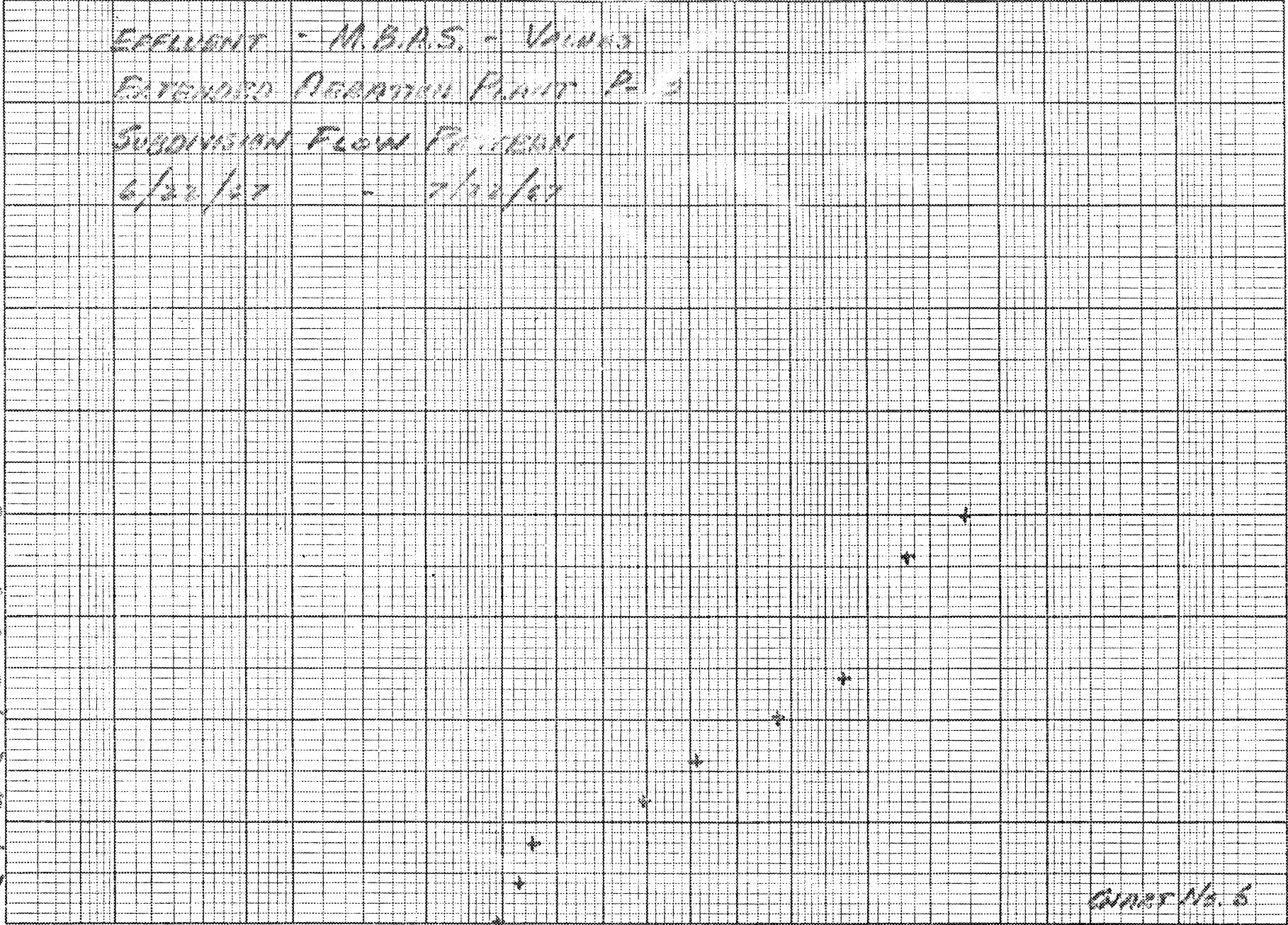
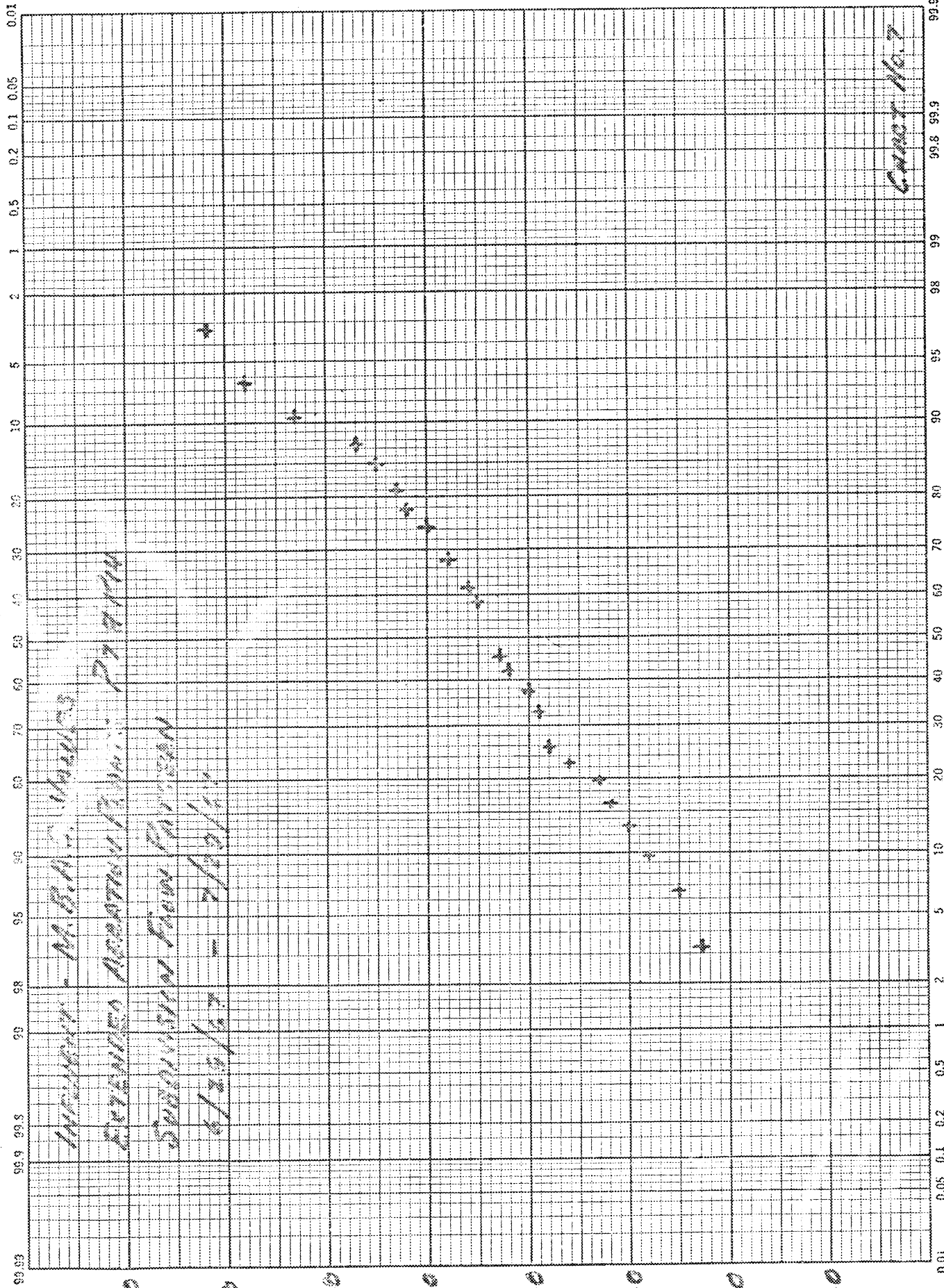


Chart No. 6

0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99

PERCENT OF VALUES EQUAL TO OR LESS THAN

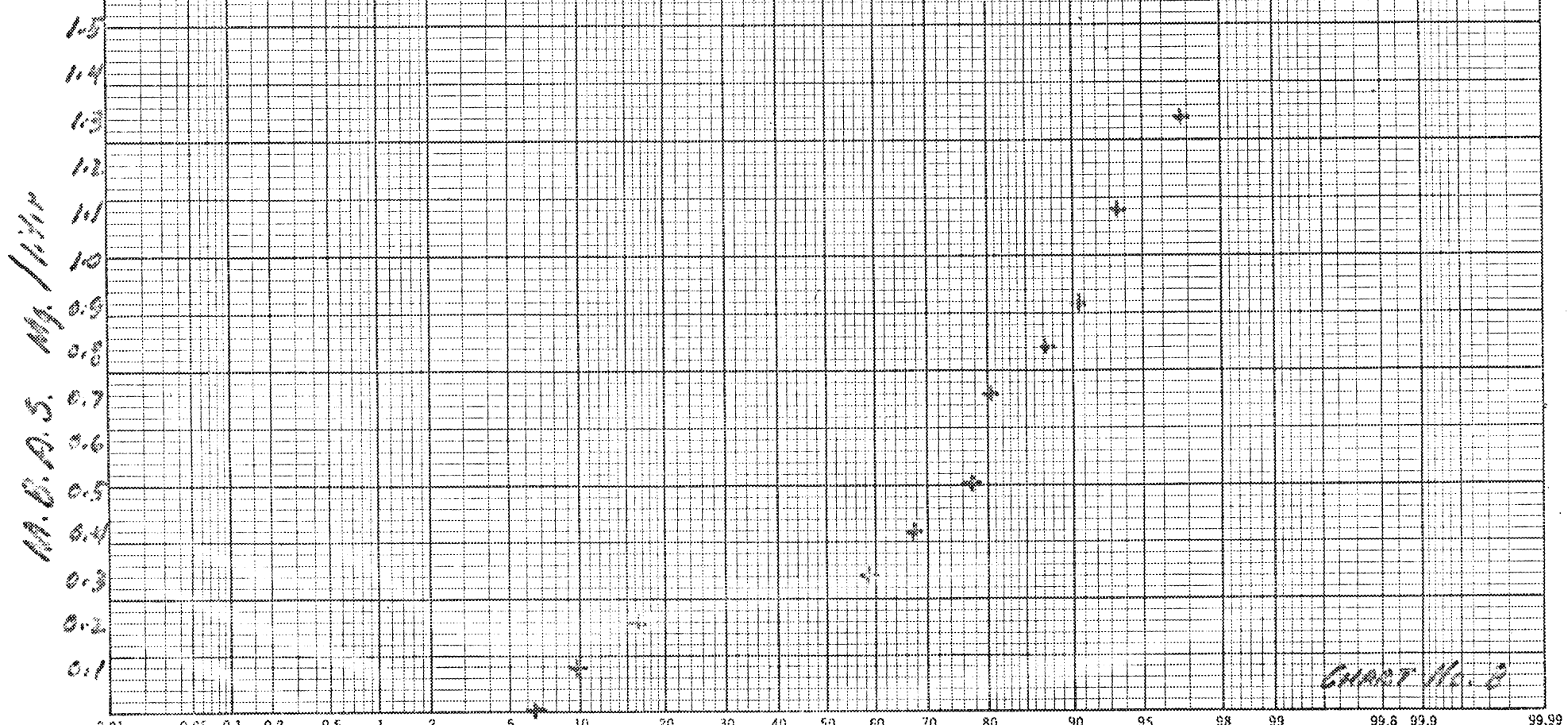


PERCENT OF VALUES EQUAL TO OR LESS THAN

Chart No. 7

99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01

EFFLUENT - M.B.D.S. - VALUES  
 EXTENDED RECORDING PLANT #17  
 SUPERVISOR FLOW RECORD  
 6/20/67 - 7/24/67



M.B.D.S. Mg./liter

CHART No. 2

PERCENT OF VALUES EQUAL TO OR LESS THAN

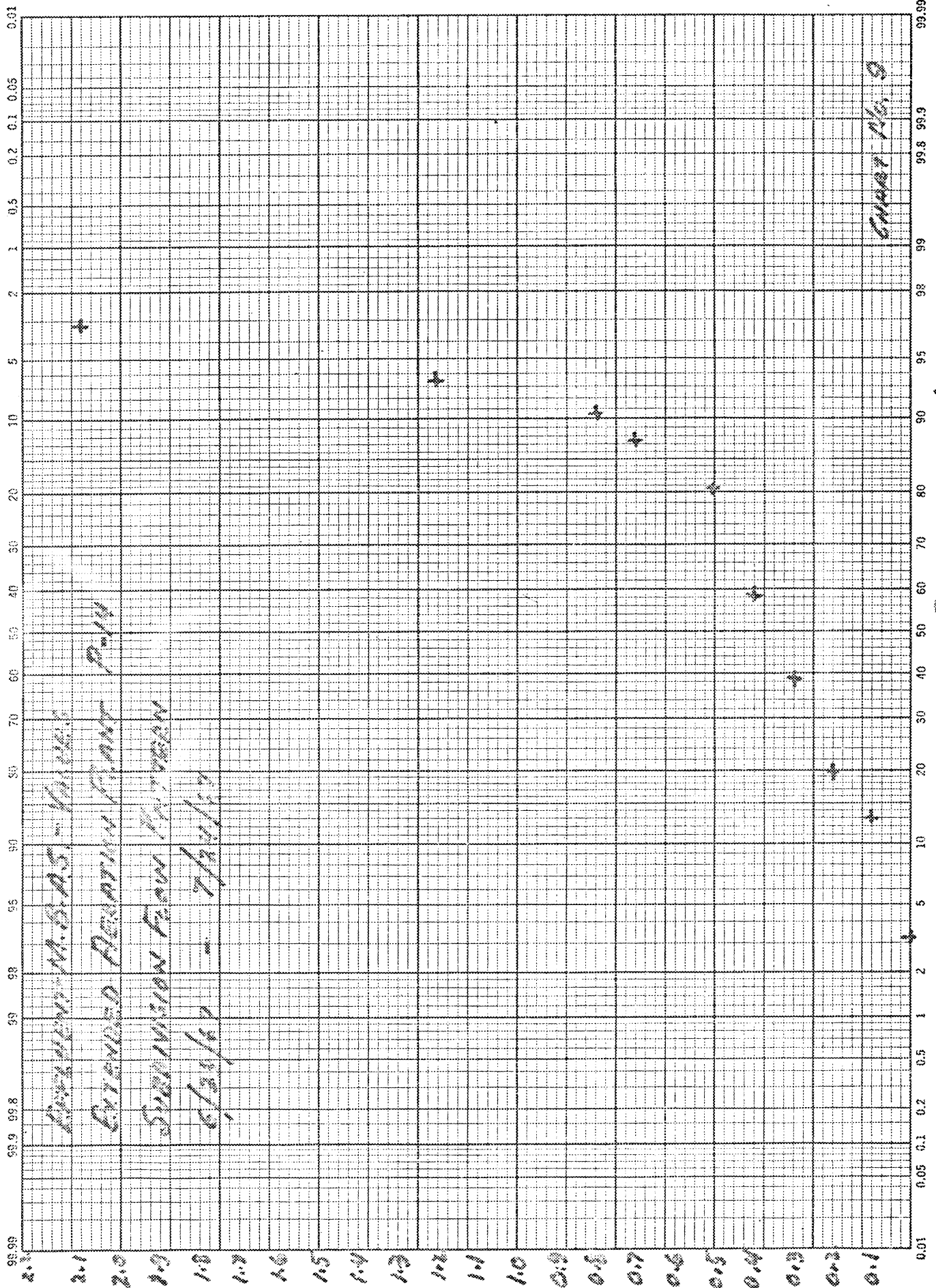


CHART No. 9

Probability vs. Time for an Losses

M.B.D.S. - 7/23/67

99.99 99.9 99.8 99 98 95 90 80 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01

MEASUREMENT M.B.S. VALUES

EXTENDED PROBATION POINTS P-7, P-8, P-10, P-15

SCHOOL FROM PROBATION

7/30/67 - 5/2/67

M.B.S. Mg./liter

8.0  
7.0  
6.0  
5.0  
4.0  
3.0  
2.0  
1.0

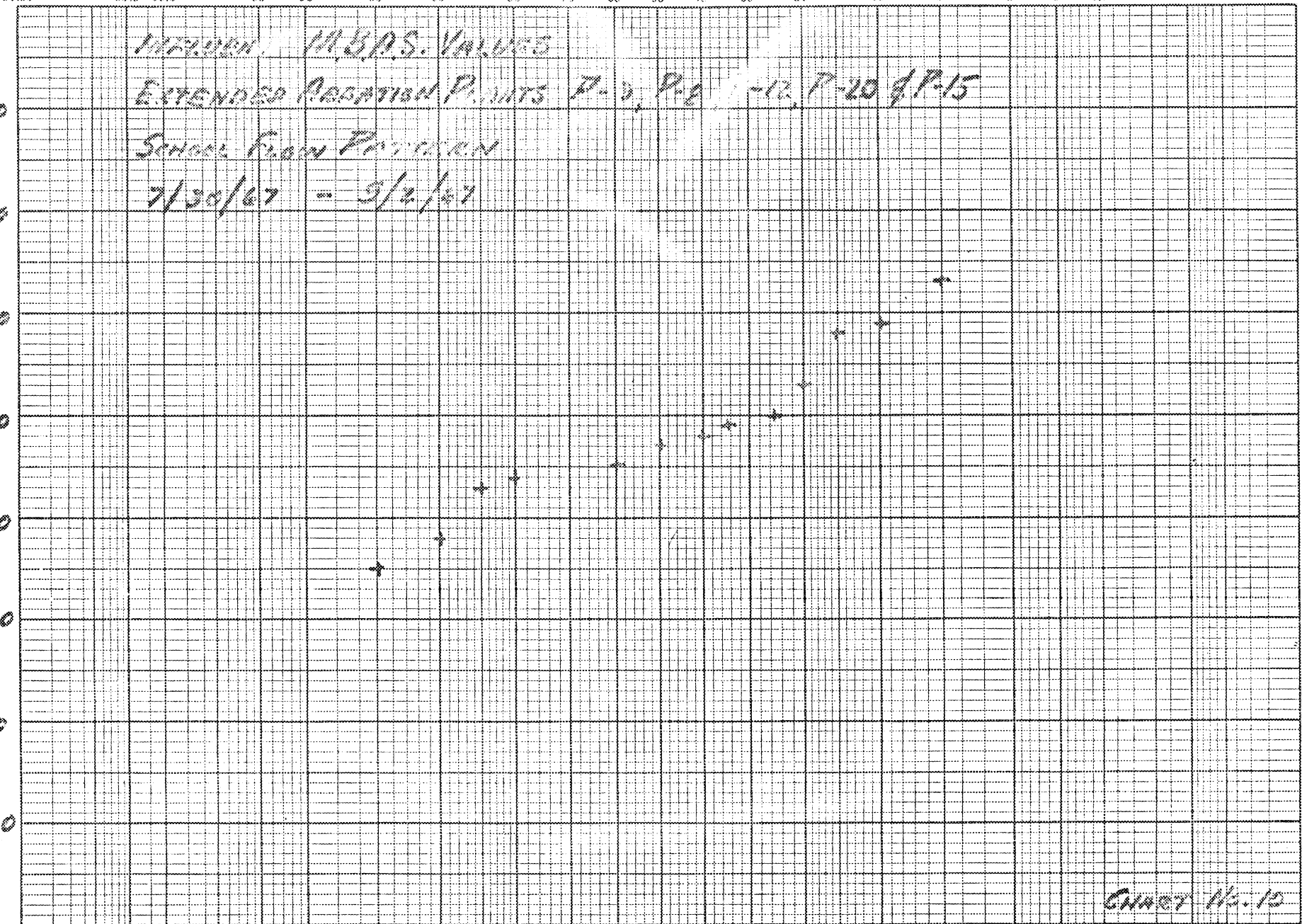
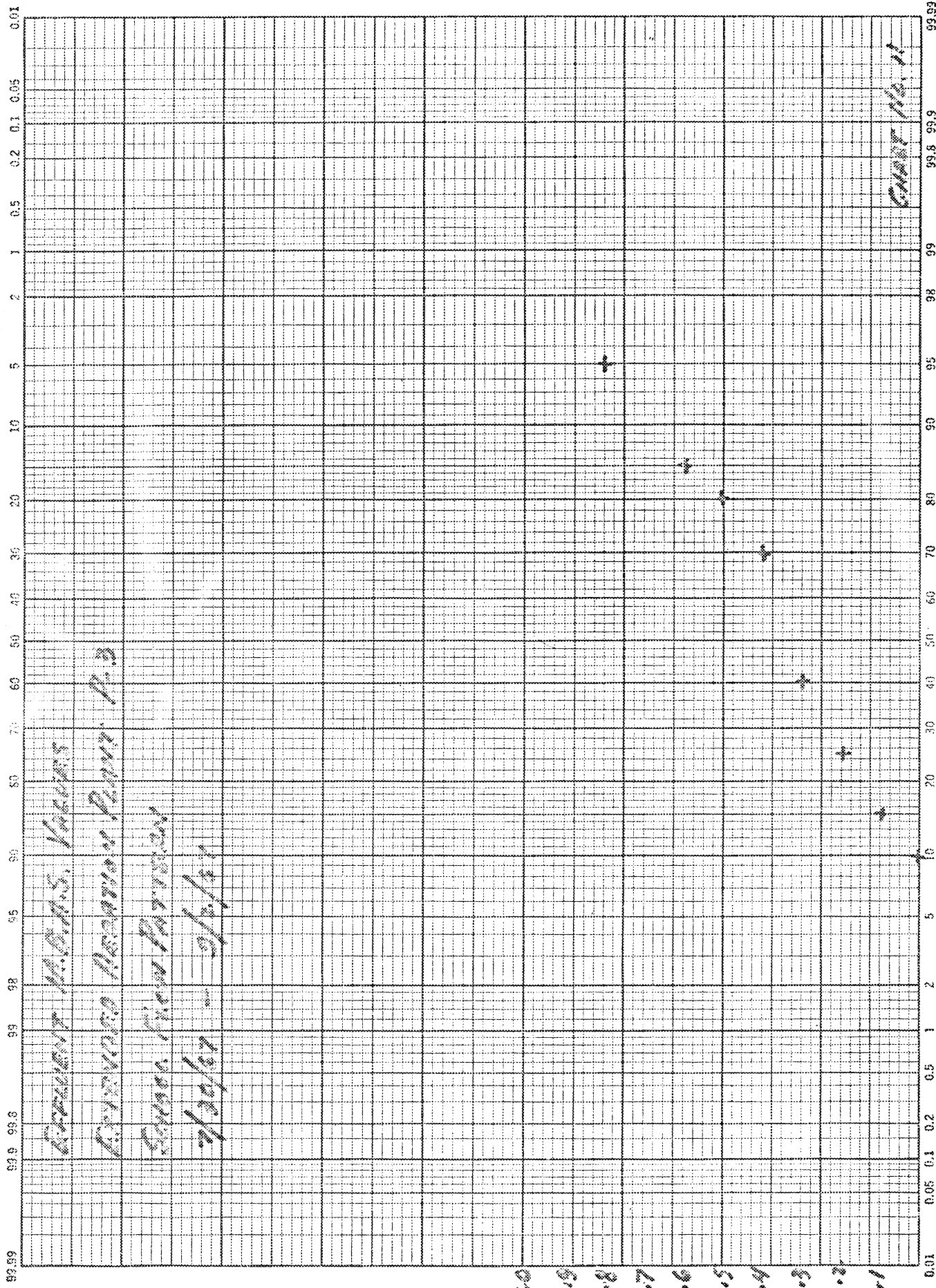


Chart No. 15

0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99

PERCENT OF VALUES EQUAL TO OR LESS THAN



PERCENTAGE OF VALUES EQUAL TO OR LESS THAN

99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01

EXHIBIT M.A.S. Vol. 102  
EXTENDED RESOLUTION TEST P. 5  
SAMPLING PATTERN  
7/30/47 - 9/2/47

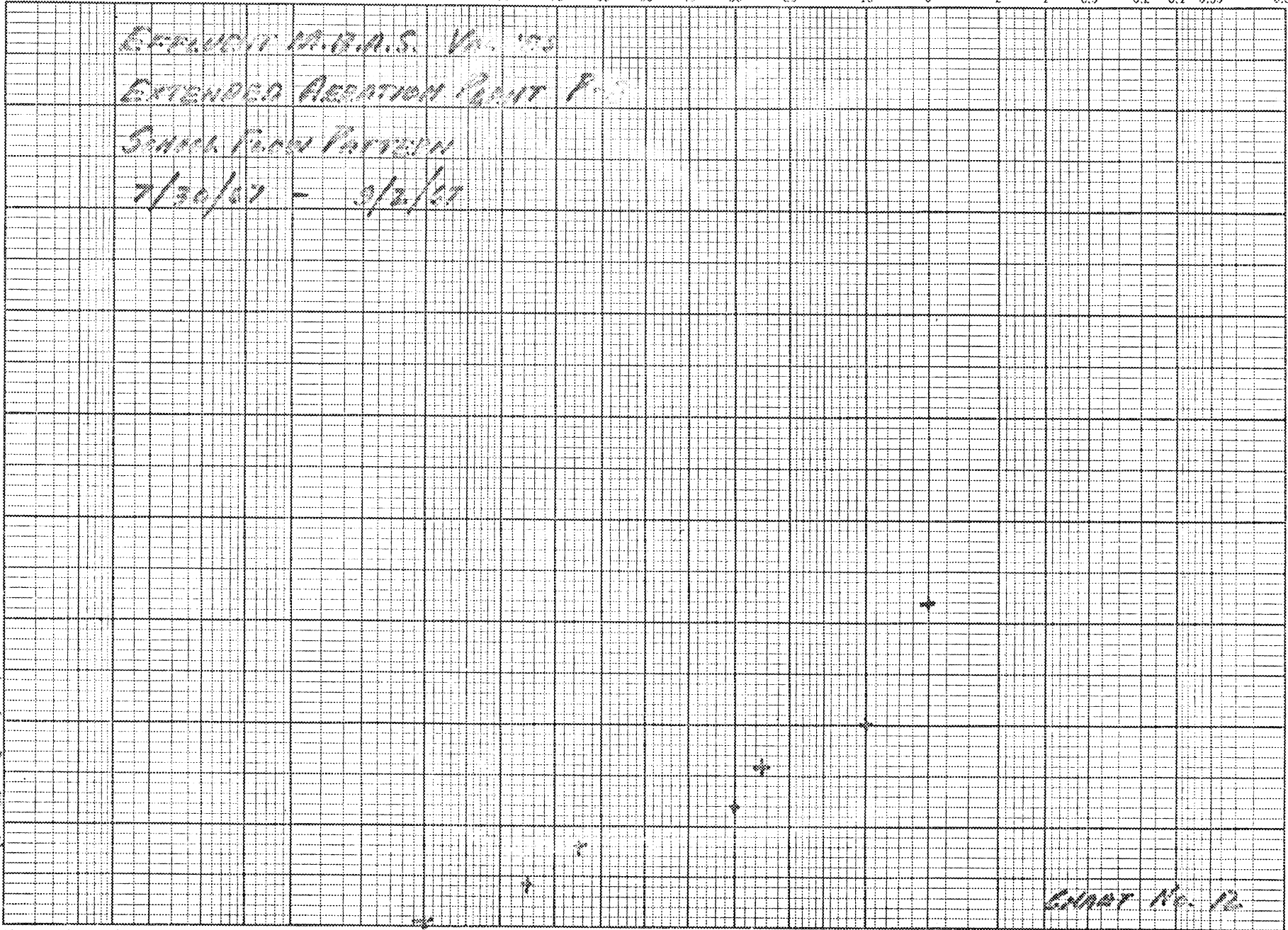
M.S.P.S. - M<sub>1</sub>/f<sub>1</sub>μm

10  
4.0  
2.0  
0.8  
0.5  
0.4  
0.3  
0.2  
0.1

0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99

PERCENT OF VALUES EQUAL TO OR LESS THAN

CHART No. 10



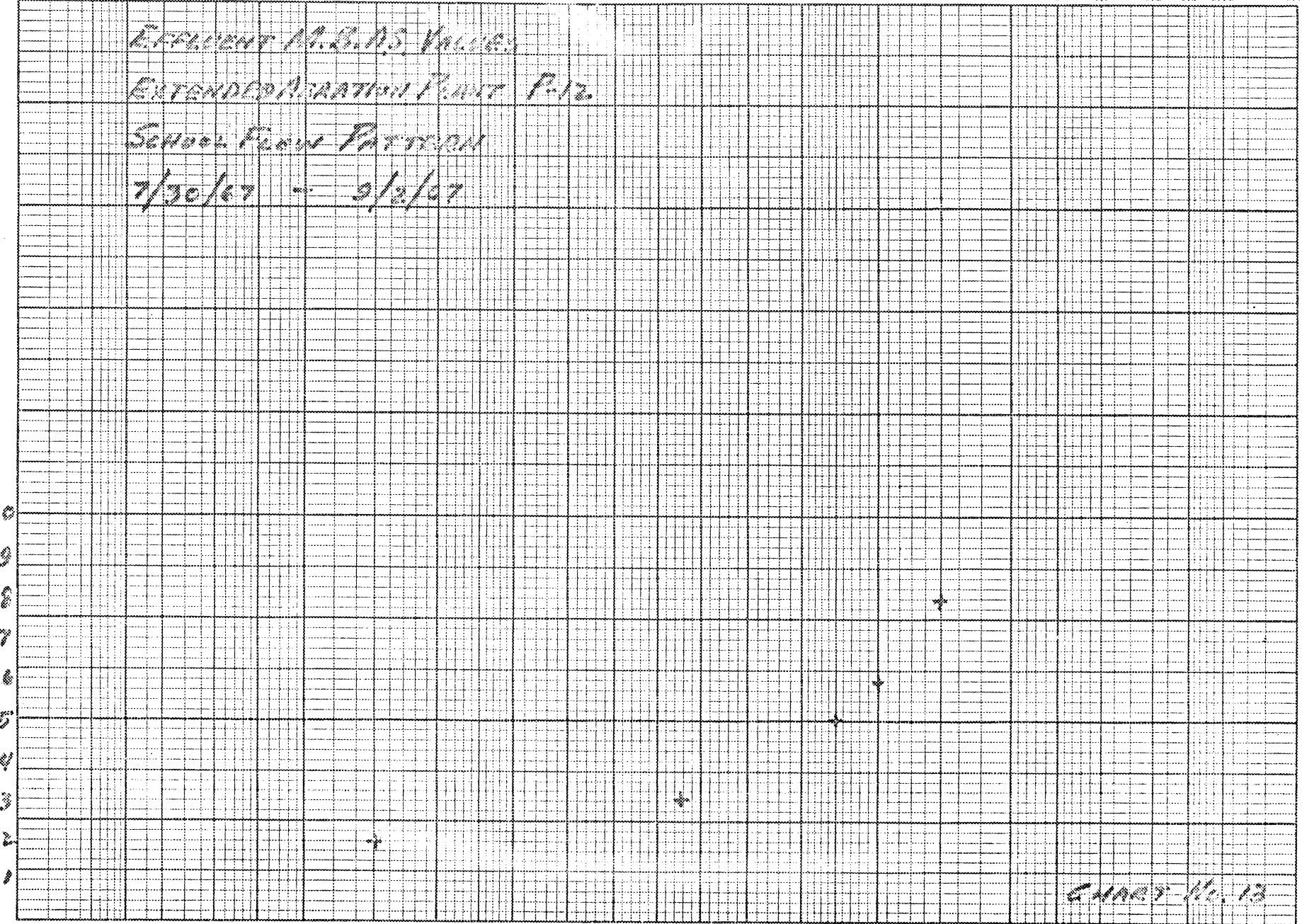


99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01

*EFFICIENT M.G.A.S. VALUE*  
*EXTENDED OPERATION PERMIT P-12*  
*SCHOOL FLOW PATTERN*  
*7/30/67 - 9/2/67*

*M.G.A.S. Magnitude*

0.1  
 0.2  
 0.3  
 0.4  
 0.5  
 0.6  
 0.7  
 0.8  
 0.9  
 1.0



*Chart No. 13*

0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99

*PERCENT OF VALUES EQUAL TO OR LESS THAN*

99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01

EFFICIENCY - M.B.A.S. VALUES  
EXTENDED READING PLANT P 15  
SINCE FROM ...  
7/30/57 - 9/2/57

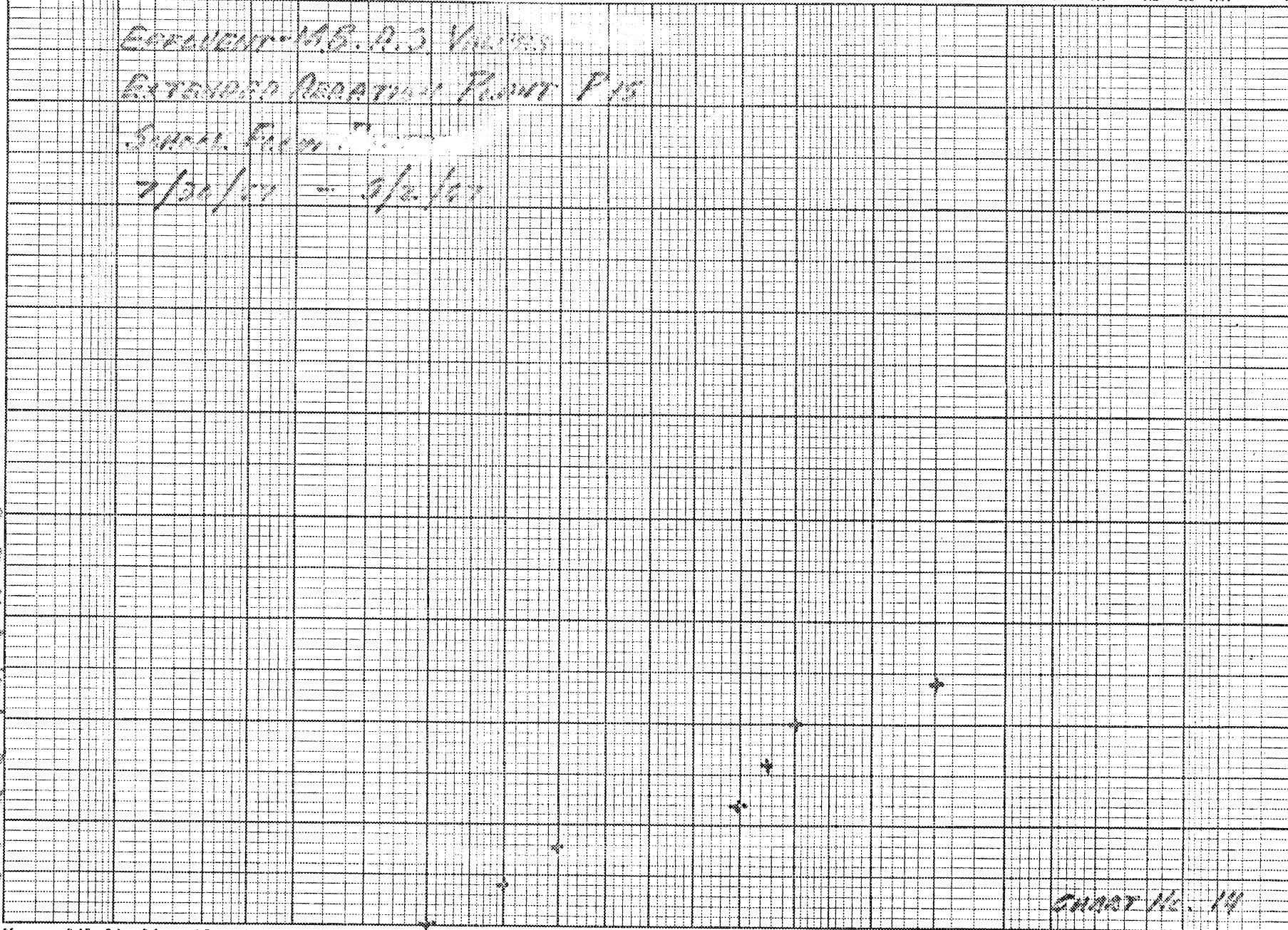
M.B.A.S. mg./ft<sup>3</sup>

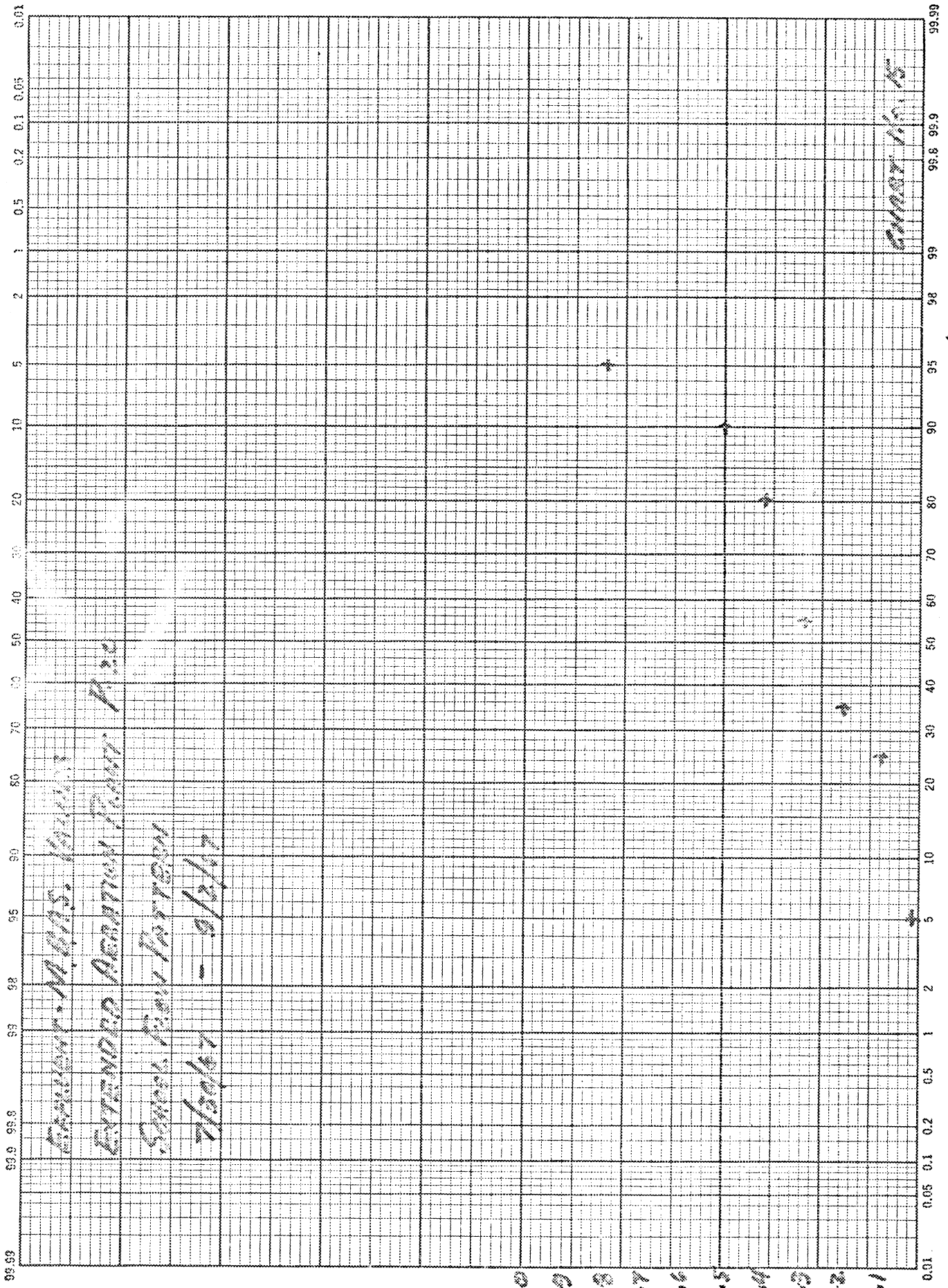
1.0  
0.9  
0.8  
0.7  
0.6  
0.5  
0.4  
0.3  
0.2  
0.1

0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99

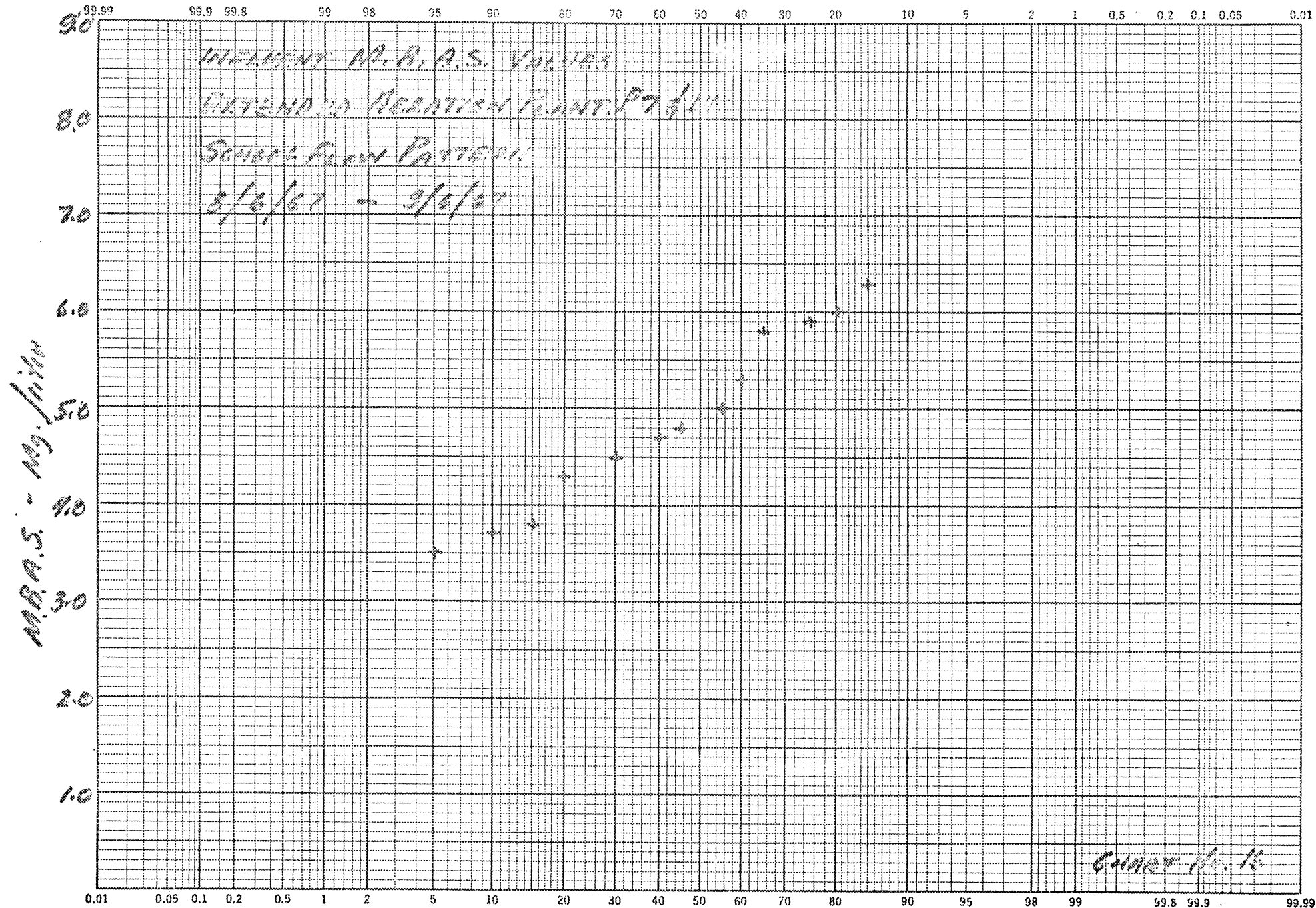
PERCENT OF VALUES EQUAL TO OR LESS THAN

CHART No. 14





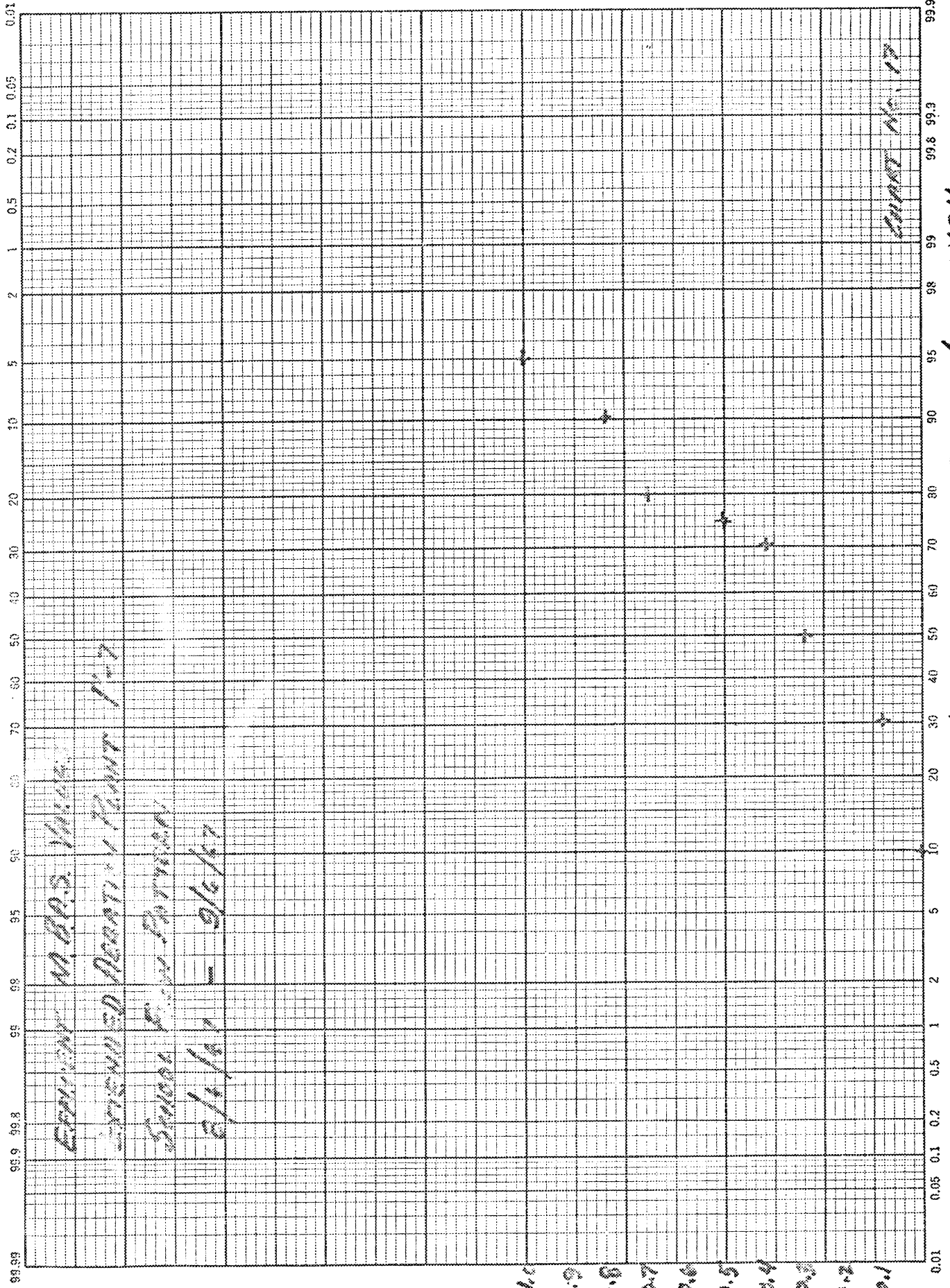
PERCENTAGE VALUES EQUAL TO OR LESS THAN



M.B.A.S. - Mg./Inch

CHART No. 16

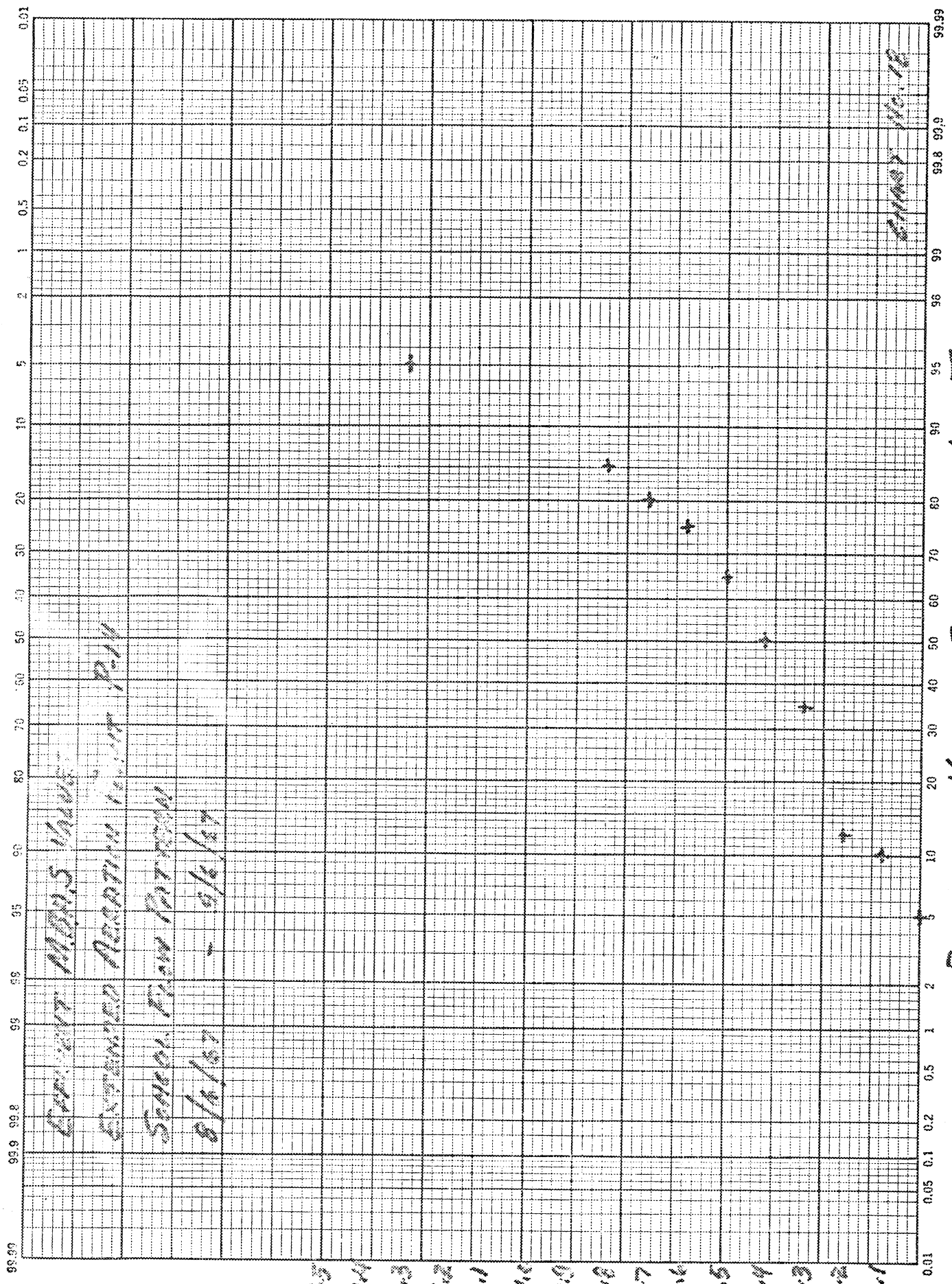
PERCENT OF VALUES EQUAL TO OR LESS THAN



10  
 5.0  
 2.0  
 1.0  
 M.B.R.S.  
 0.5  
 0.2  
 0.1

PERCENT OF VALUES EQUAL TO OR LESS THAN

CHART NO. 17



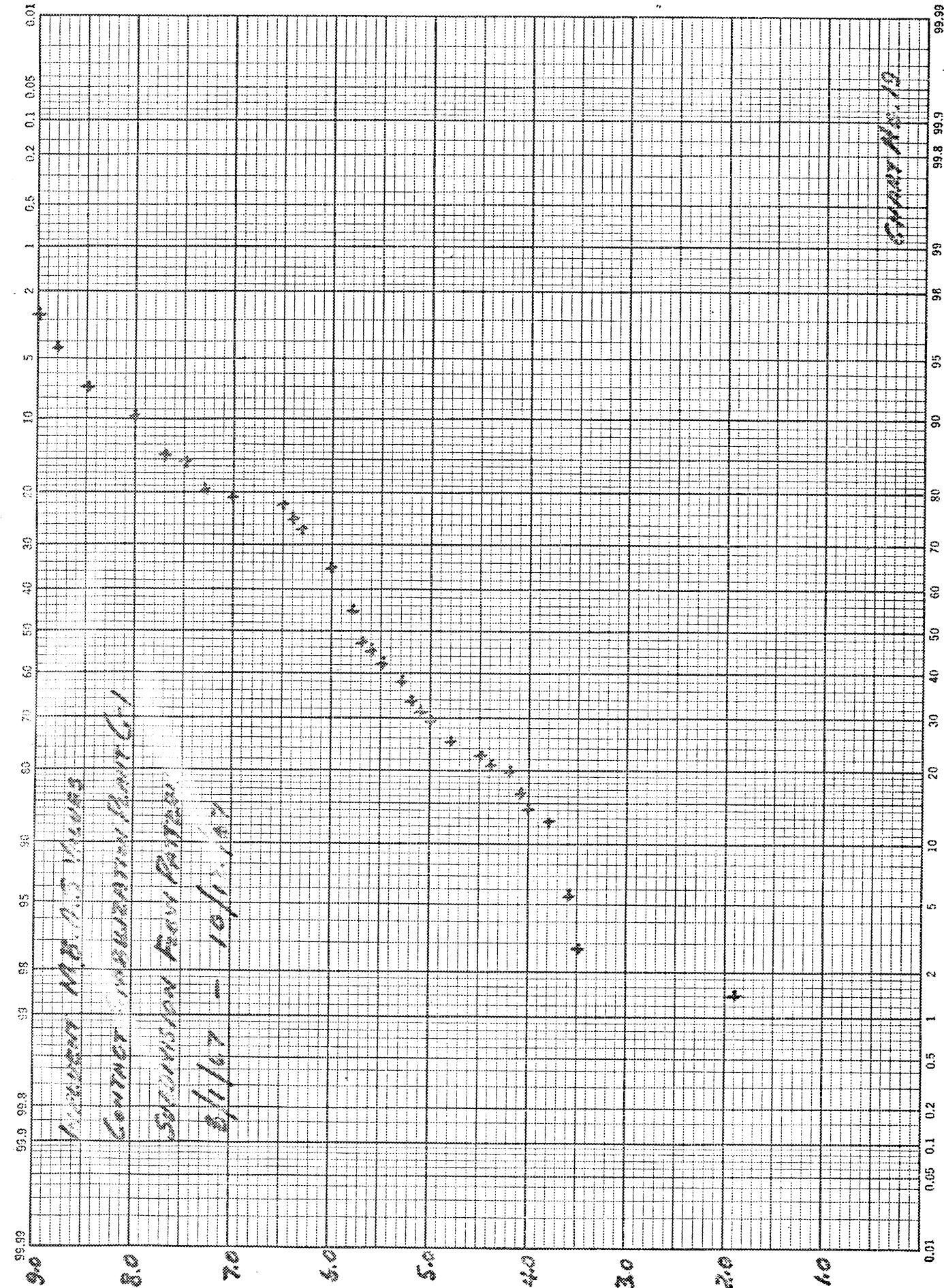
PERCENT OF VALUES EQUAL TO OR LESS THAN

EXPERIMENT M.M.S. VALUES  
 EXPERIMENTAL ACCEPTANCE LIMIT P.M.  
 SPECIAL PLAN PATTERNS  
 8/1/57 - 9/4/57

1.5  
 1.4  
 1.3  
 1.2  
 1.1  
 1.0  
 0.9  
 0.8  
 0.7  
 0.6  
 0.5  
 0.4  
 0.3  
 0.2  
 0.1

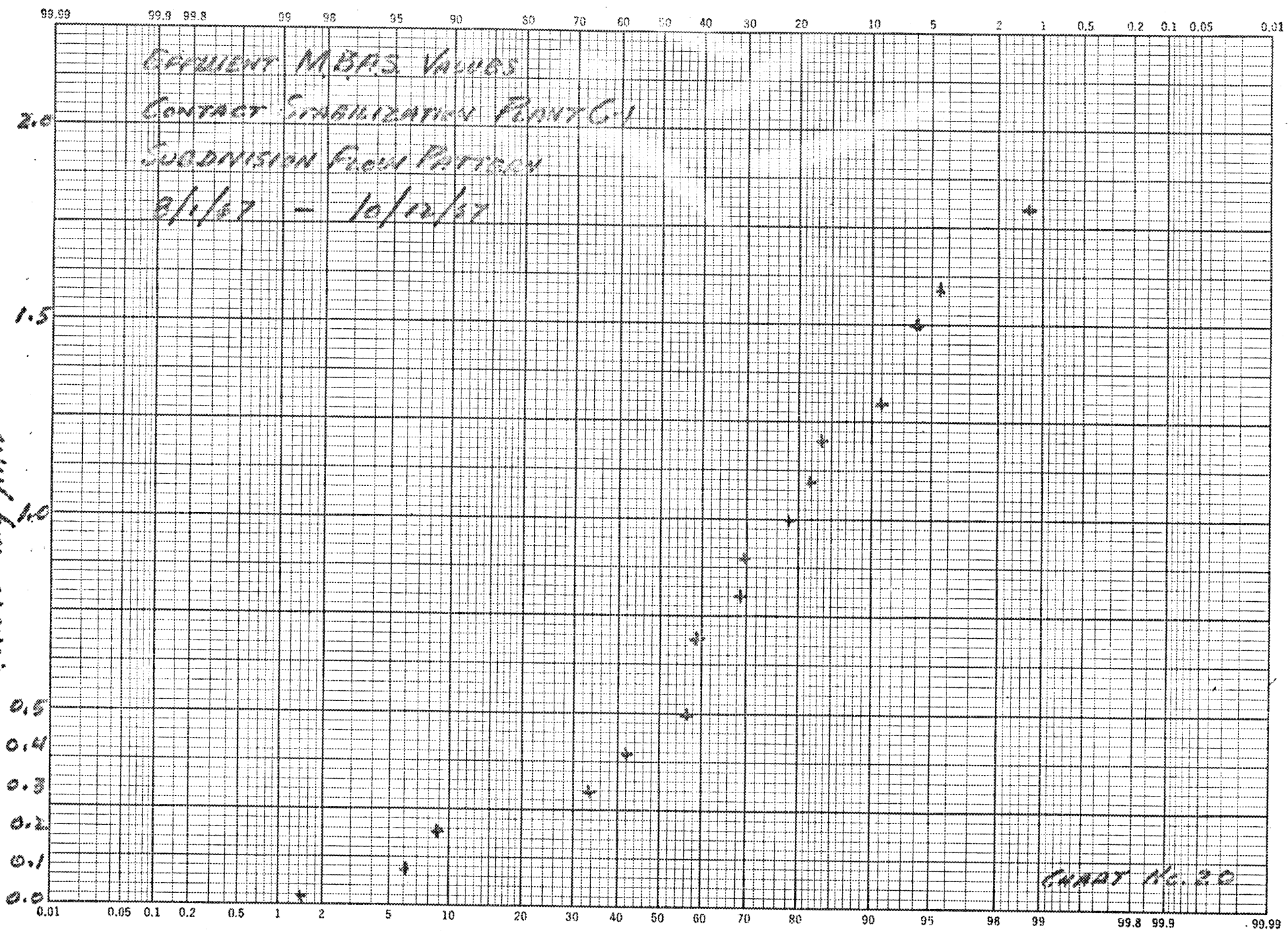
M.B.D.S. - M.A./L.H.

EXPERIMENTAL



M.B.P.S. %/MIN

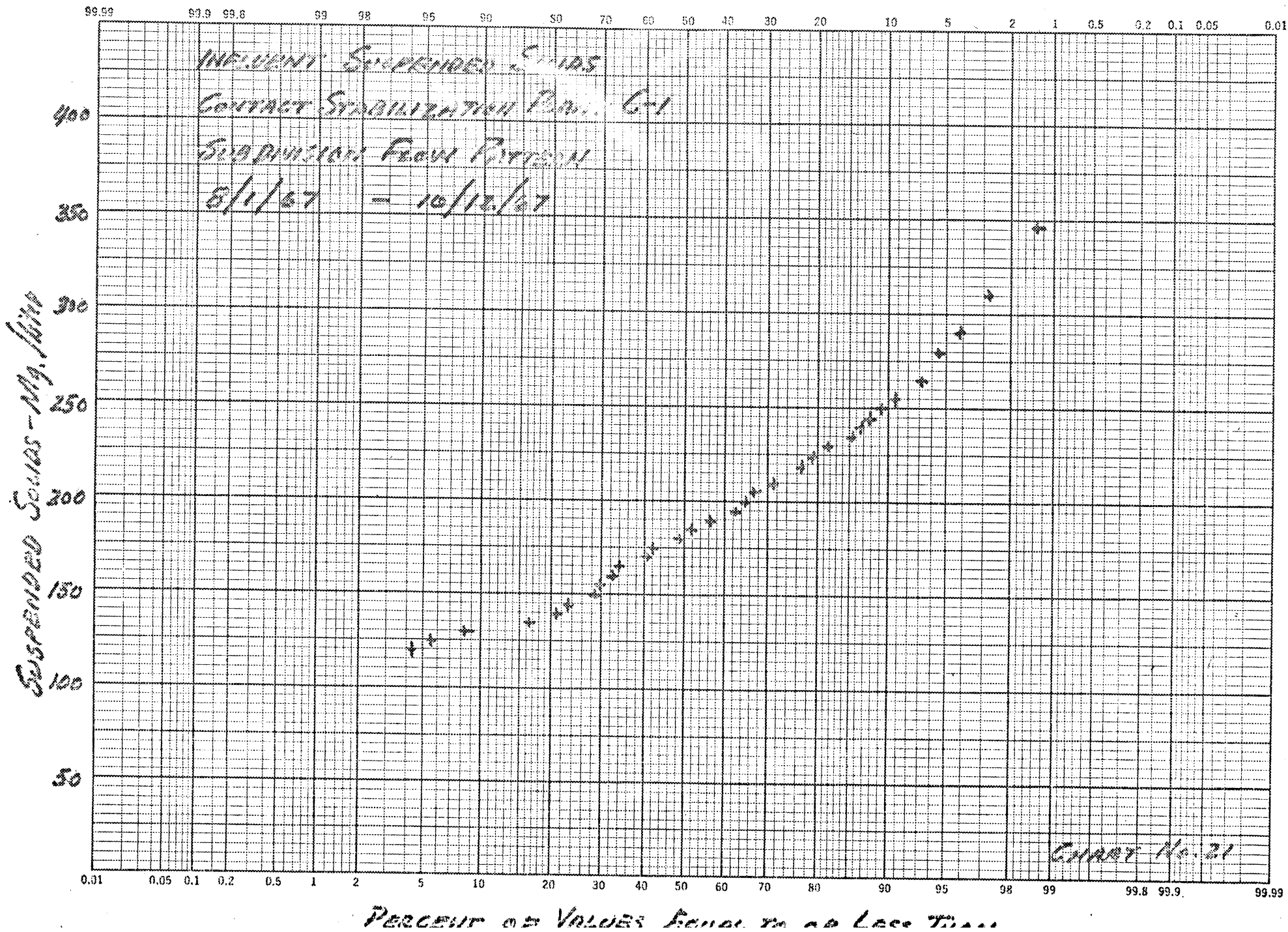
PERCENT OF VALUES EQUAL TO OR LESS THAN

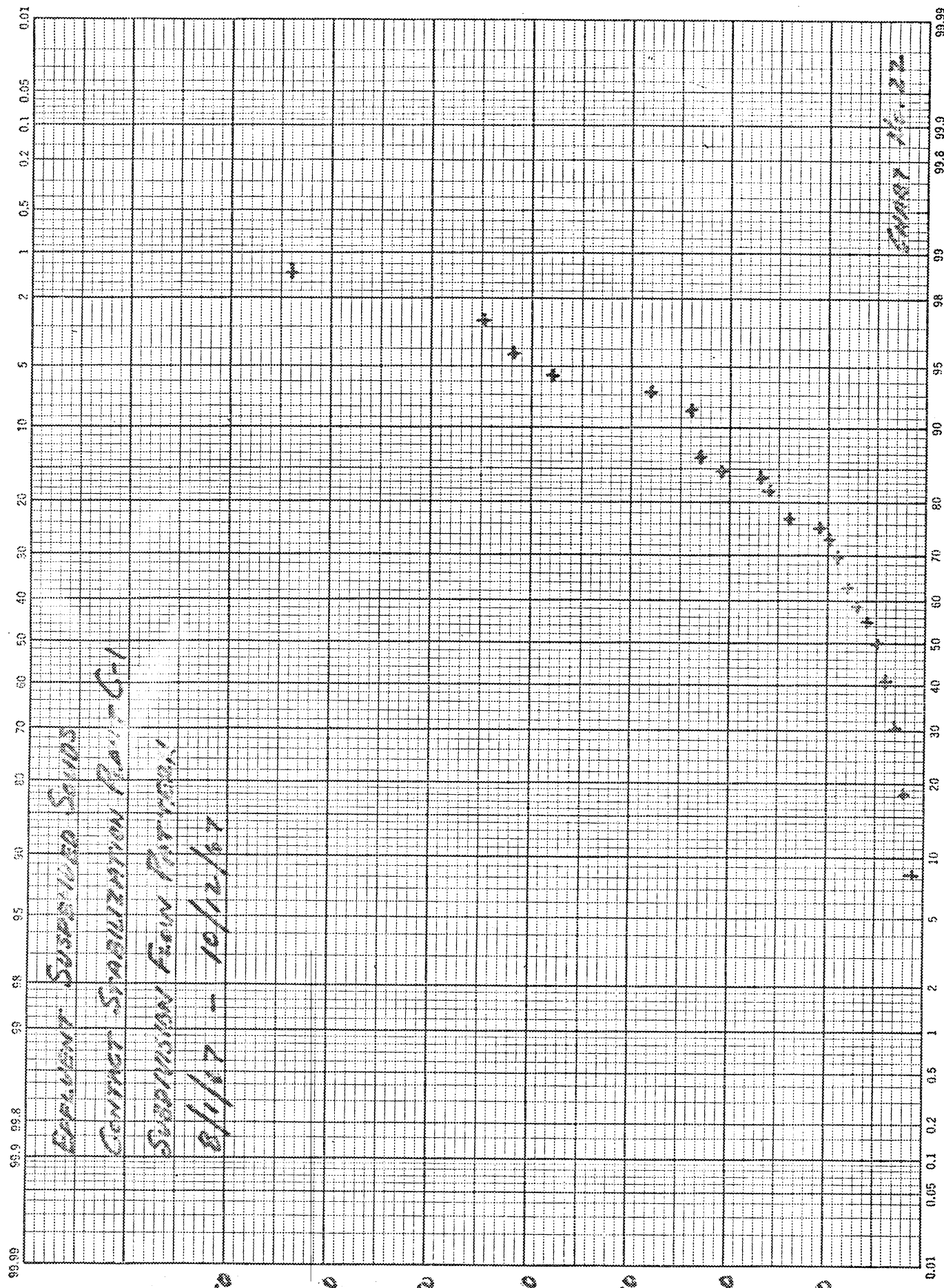


*PERCENT OF VALUES EQUAL TO OR LESS THAN*

*CHART No. 20*



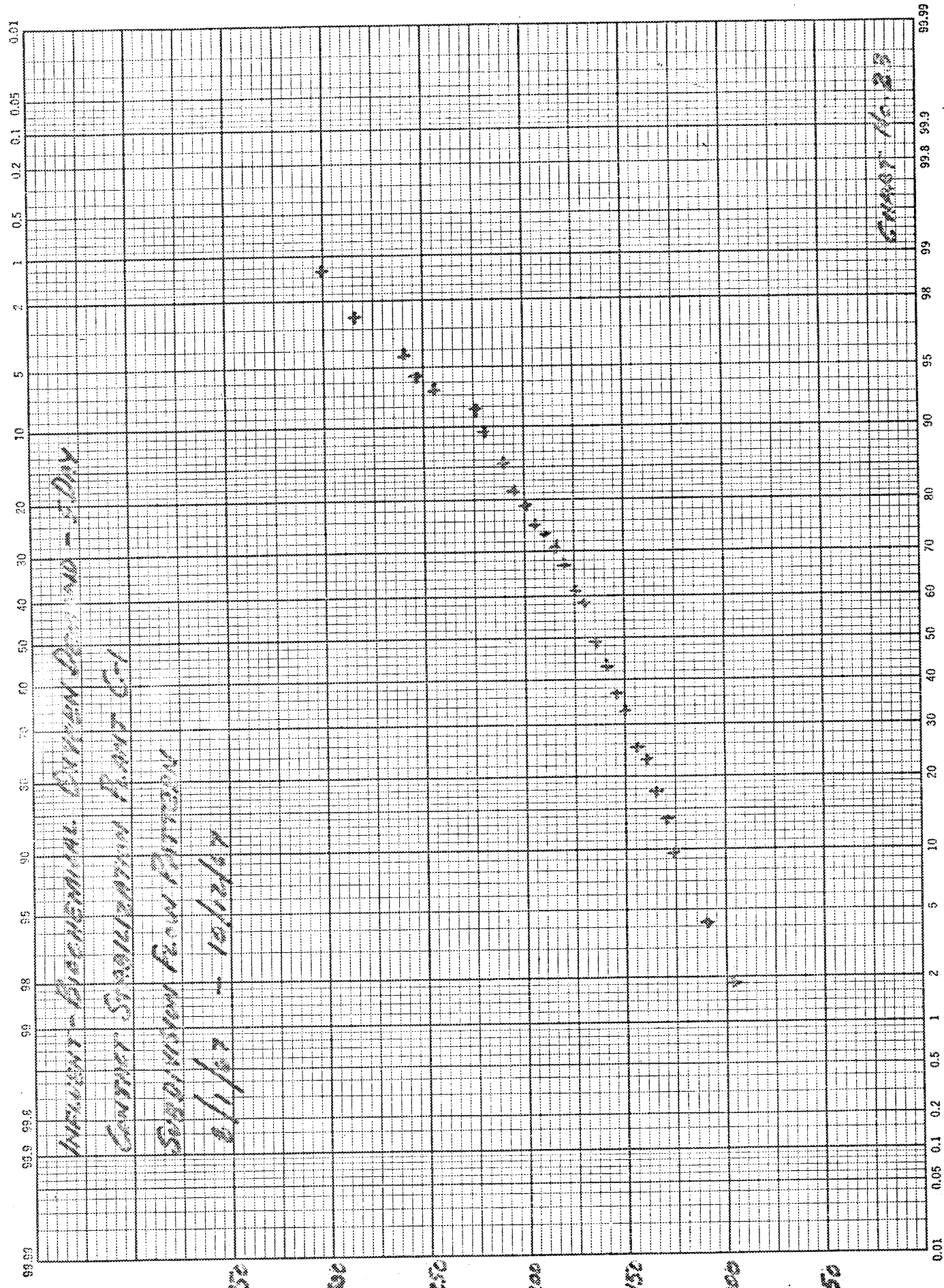




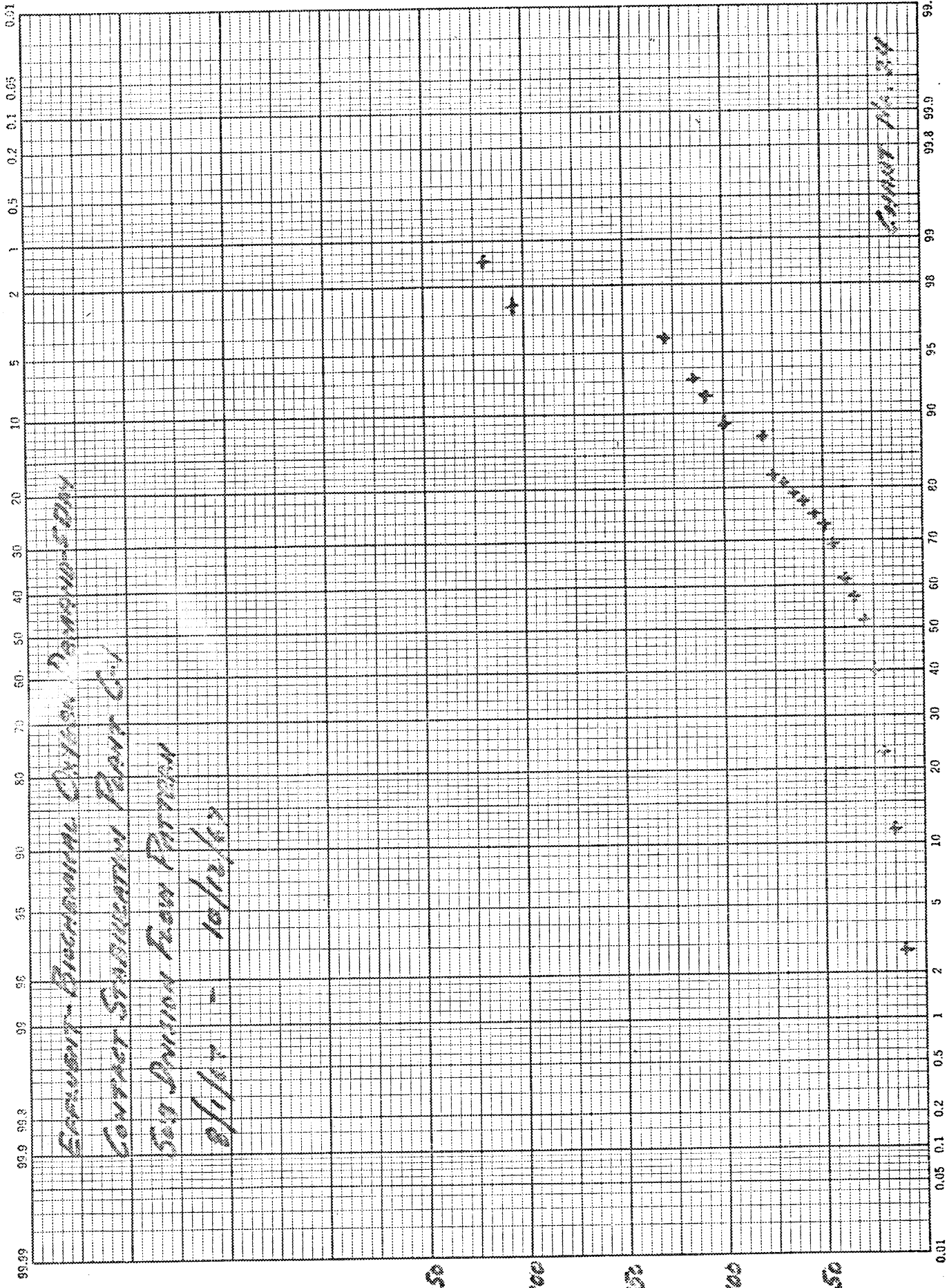
EFFLUENT SUSPENDED SOLIDS  
 CONTROL STABILIZATION PLANT  
 SUSPENSION FROM TITRATION  
 8/1/17 - 10/12/17

CHART 16.22

Percent of Values Equal to or Less Than

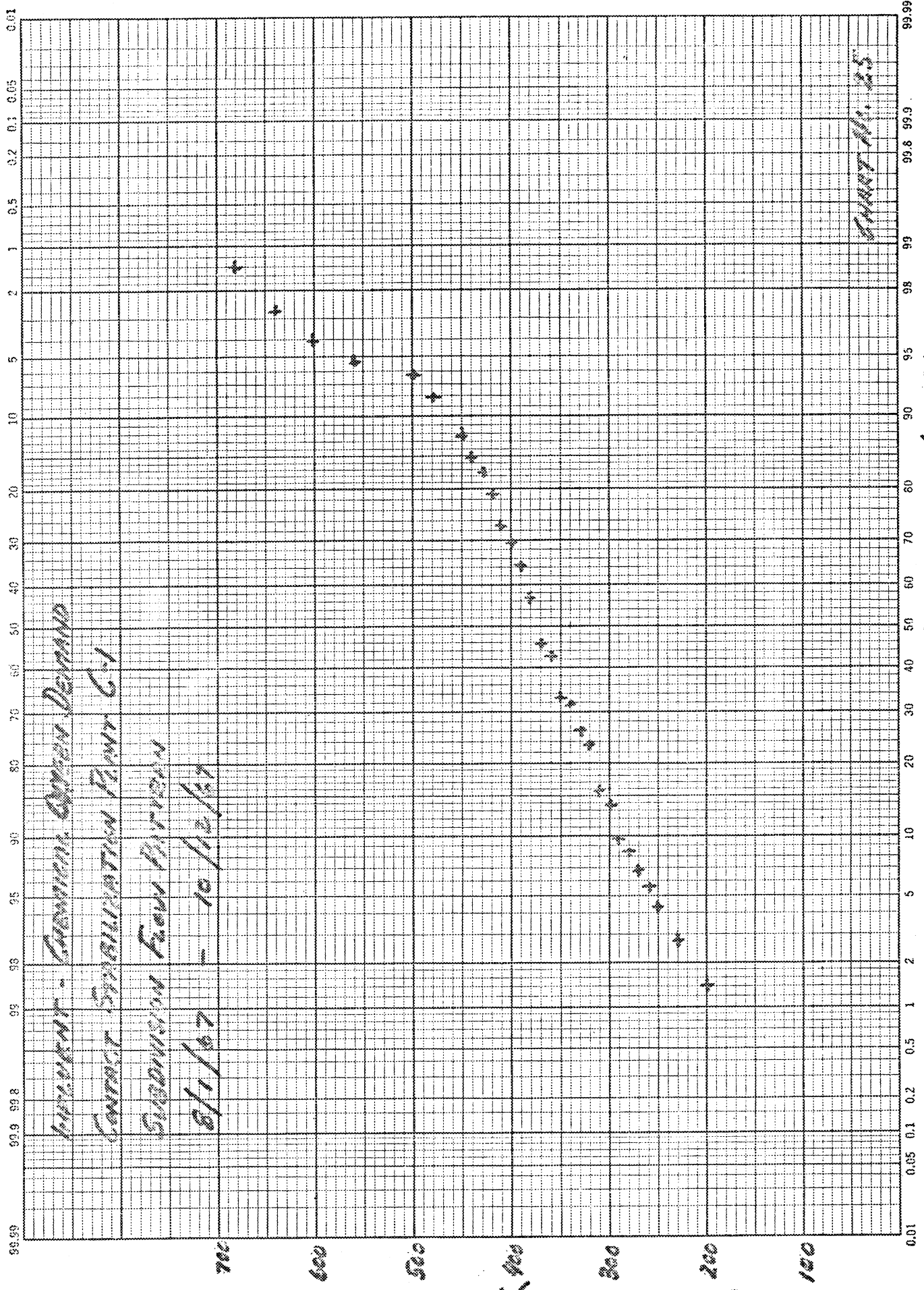


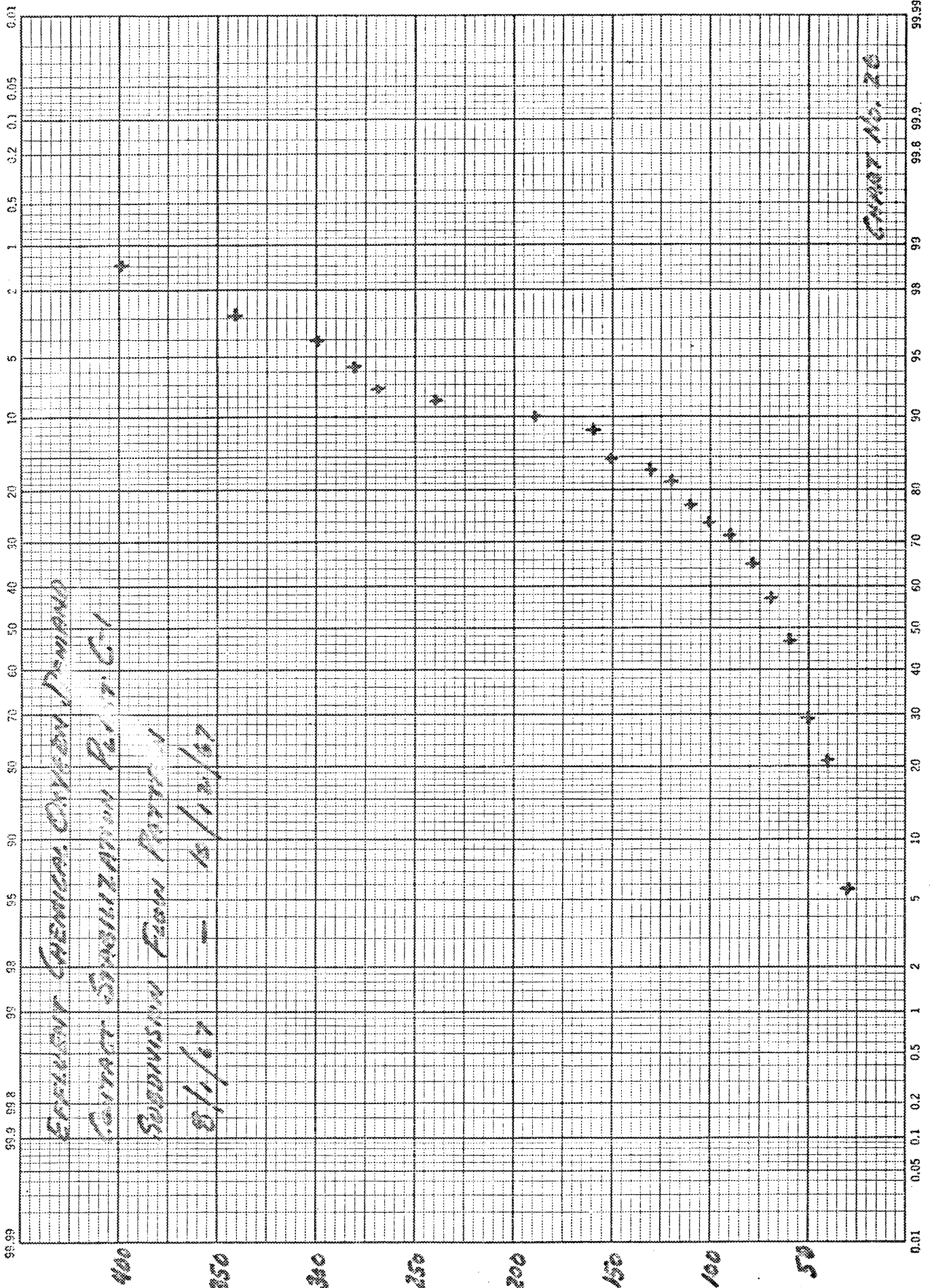
PERCENT OF VALUES EQUAL TO OR LESS THAN



EXPERIMENTAL PROCEDURE  
 CONTRACT SPECIFICATION PART C-1  
 500 DOLLAR FEED PROGRAM  
 8/1/47 - 10/12/47

8/1/47 - 10/12/47





PERCENT OF VALUES EQUAL TO OR LESS THAN

and found present, but they were not thought to be great enough in quantity to cause the problems that were being experienced. This contact stabilization plant was then emptied of its contents and flushed and disinfected. It was then restarted and the second plant (C-2) which had been operated as a contact stabilization plant in the early part of the year was also placed in operation. Both plants were again operated on a "steady state" flow pattern. The heavy scum was visibly improved after these two plants were placed back in service, but their removal efficiencies were not as high as they demonstrated in the first six months of 1967.

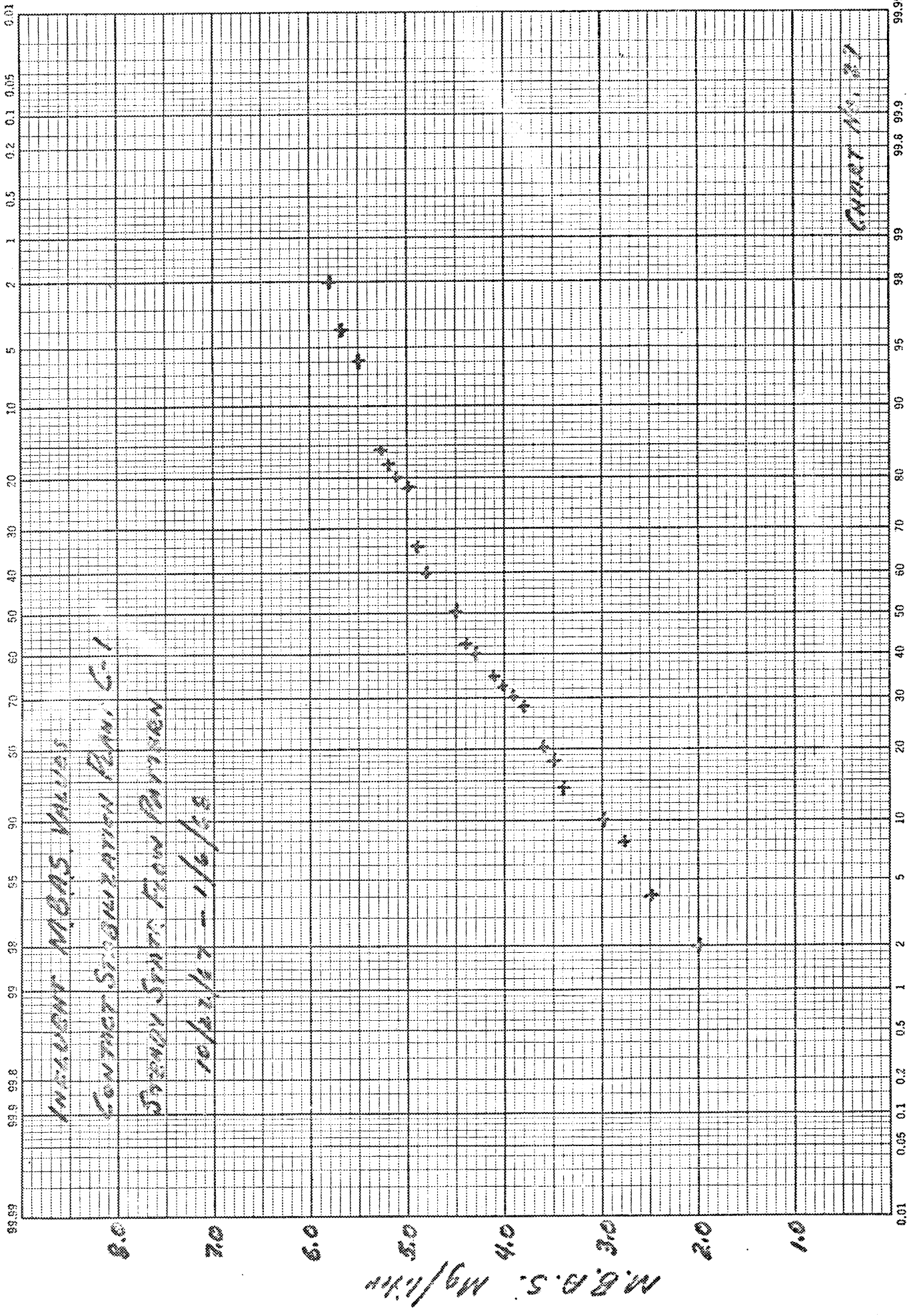
The probability plots (Charts 27 through 42) represent the latter period of operation of the two contact stabilization plants under "steady state" flow patterns. The MBAS values in the influent and effluent were comparable to the values shown for these plants in the last progress report. The suspended solids removal in plant C-1 was not quite as efficient as in the two month period previously reported on in the last progress report nor was the BOD removal efficiency. The average Chemical Oxygen Demand was approximately double the average value of the COD's in the last report for the same plant, which would point again to the possibility that some abnormal constituents were now present.

Similar comparisons were made for plant C-2 between the same two periods and similar results were observed. The Foundation staff has consulted with several experts in the field of waste water treatment, but up until the present no one has been able to identify any chemical substance that might be causing this condition by combining with the normal constituents present in the waste water.

In the last report mention was made of the recent emphasis on the removal of phosphates in waste water treatment processes. The contact stabilization plants have been monitored for phosphates in the influent to the plants and in their effluents. The average value of phosphates in the two plants influent from October through December 1967 has been 55 mg/liter while the effluent during the same period has averaged 36 mg/liter. The average removal would then be about 34.5% which is not considered adequate for the purposes of limiting eutrophication in the natural bodies of water which receive waste water discharges. The contact stabilization process does have possibilities for treating the supernatant return from the aerobic digester to remove the phosphate content before it is returned to the reaeration or stabilization tank. Measurements of the phosphates content in the supernatant in these plants indicated that the range of phosphate values in the supernatant are from 50 mg/liter to 700 mg/liter with an average value for one of the plants of 240 mg/liter of total phosphate ( $PO_4$ ) in its supernatant liquor flowing back to the digester.

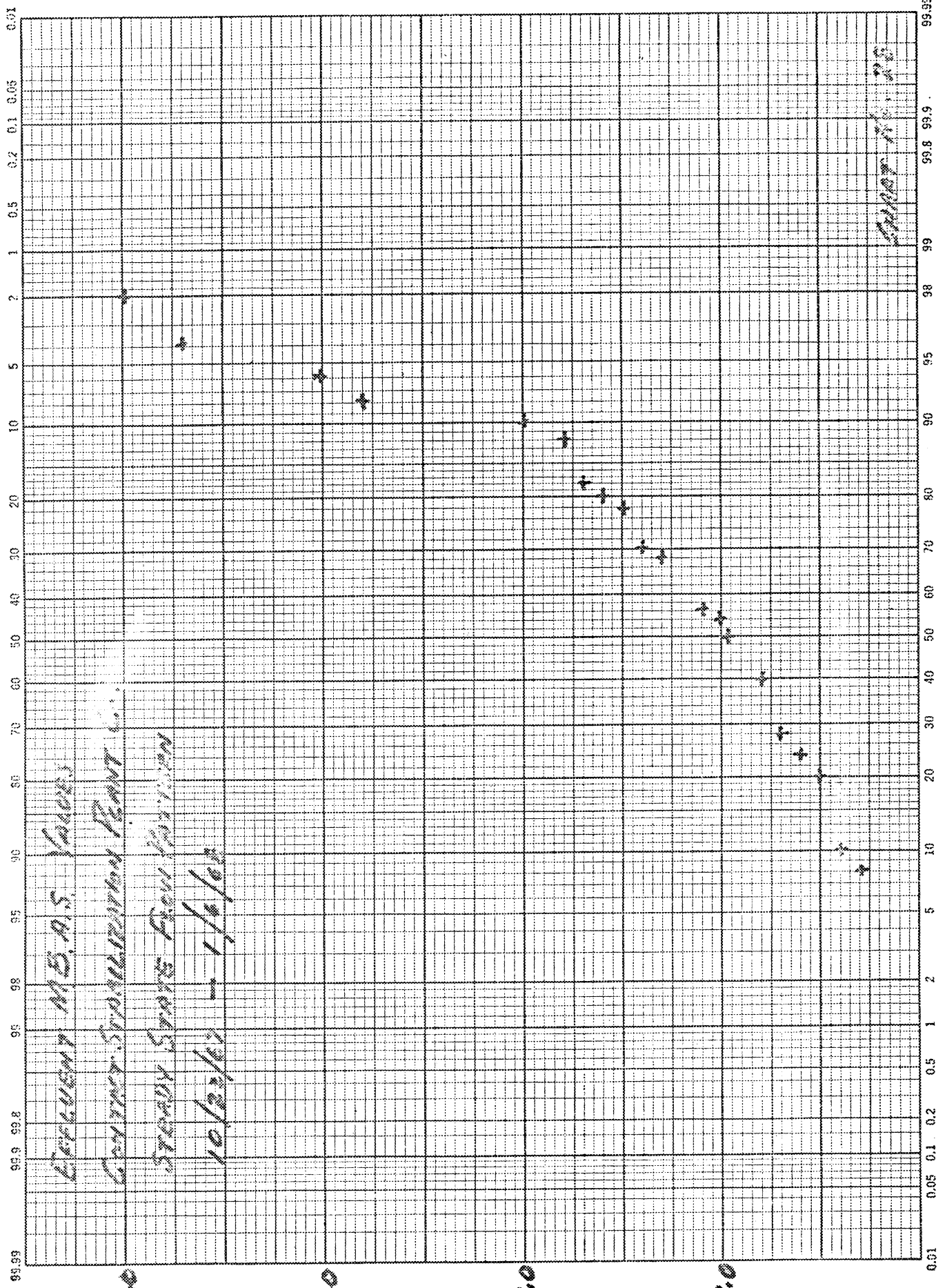
#### IV. SUMMARY

The study on the concentration and reduction of surface active agents in package sewage treatments has confirmed that these plants can secure reductions of Methylene Blue Active Substances that will result in average values being below one milligram per liter. Time of flow through the sewer system will also cause degradation and



M.B.D.S. VALUE - 10/22/77 - 1/6/78





EFFLUENT M.B.A.S. VALUES  
 CANTON SPILLWAY PLANT  
 STEADY STATE FLOW POSITION  
 10/23/68

10/23/68

This curve is based on data from 10/23/68

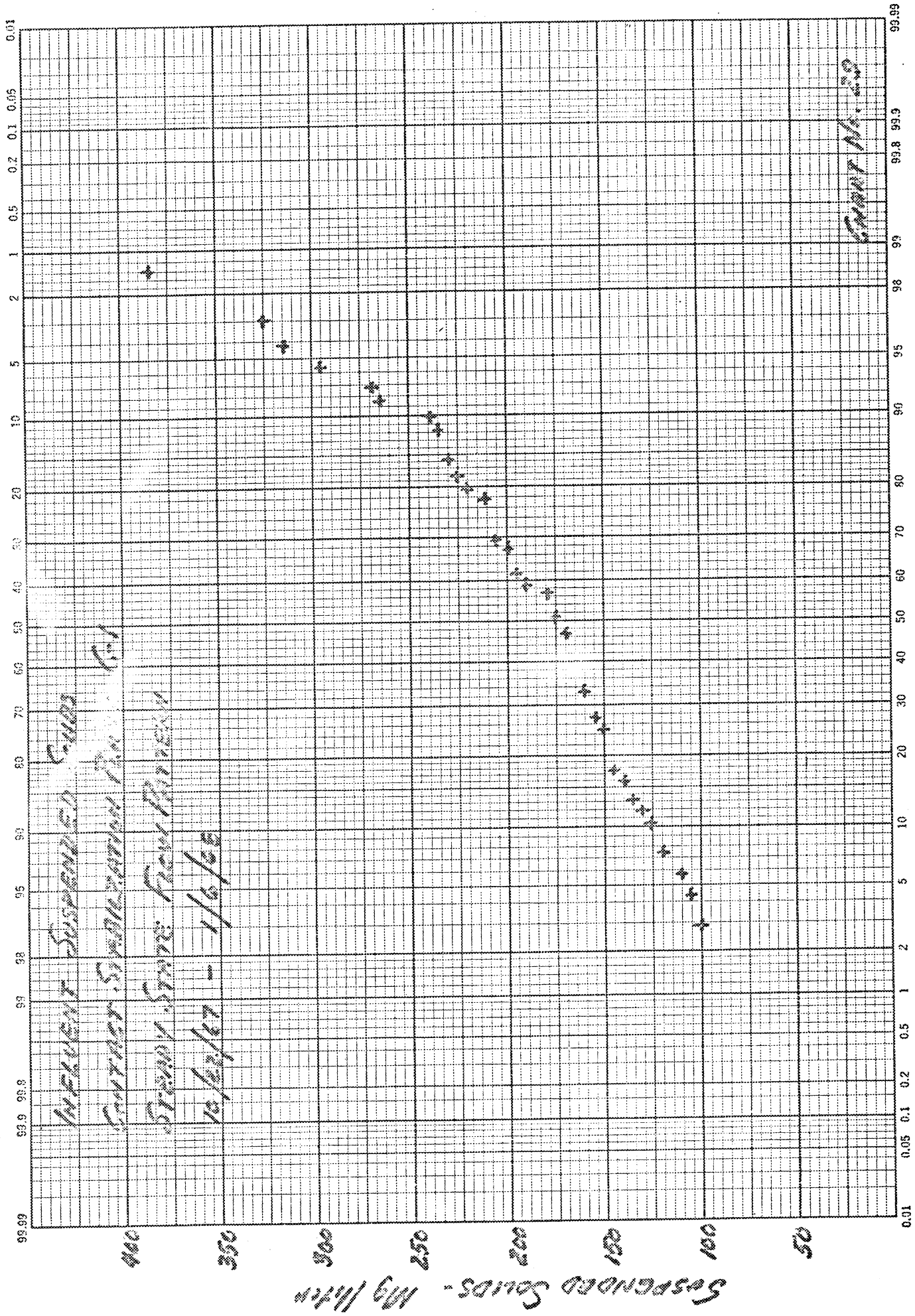
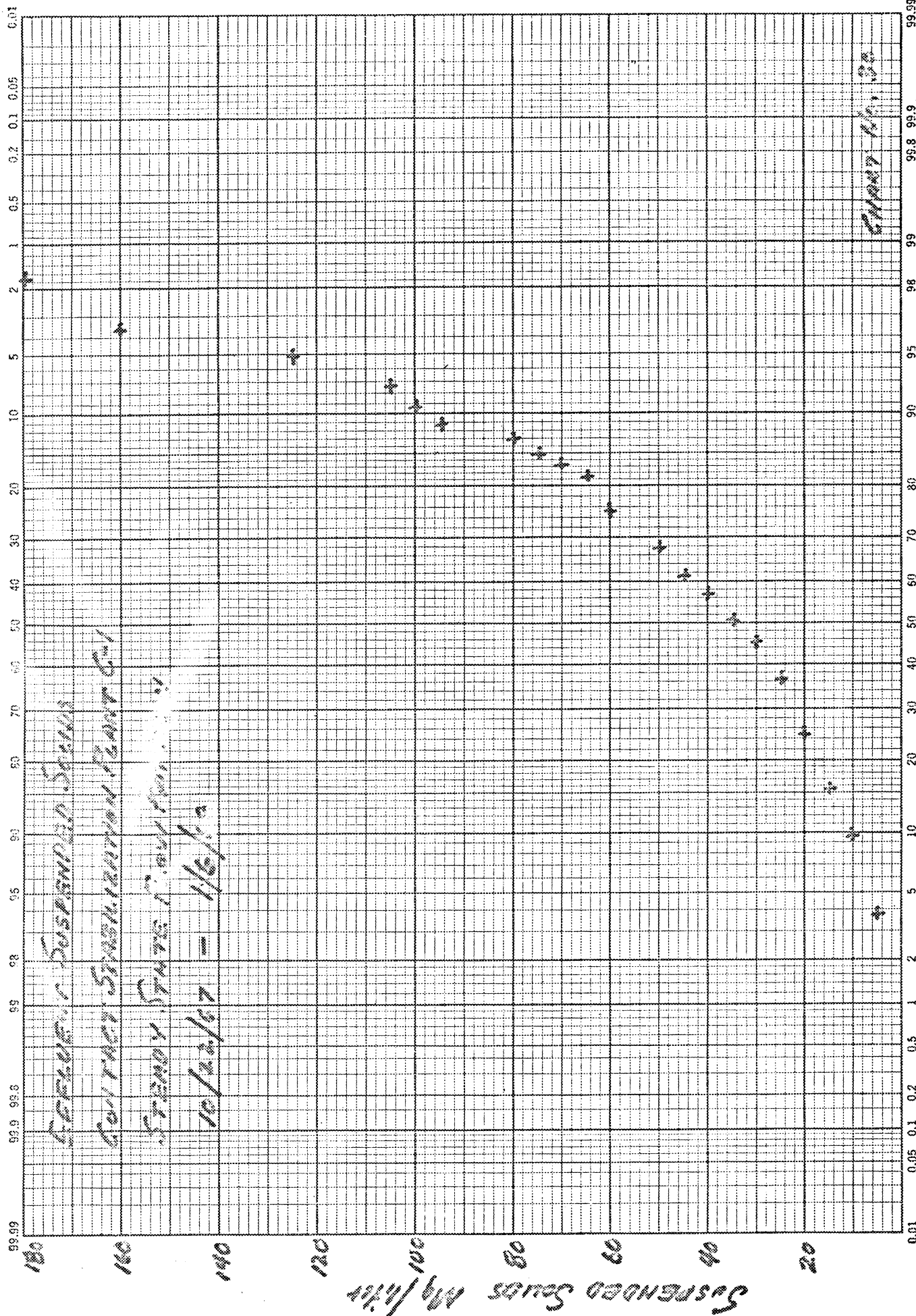


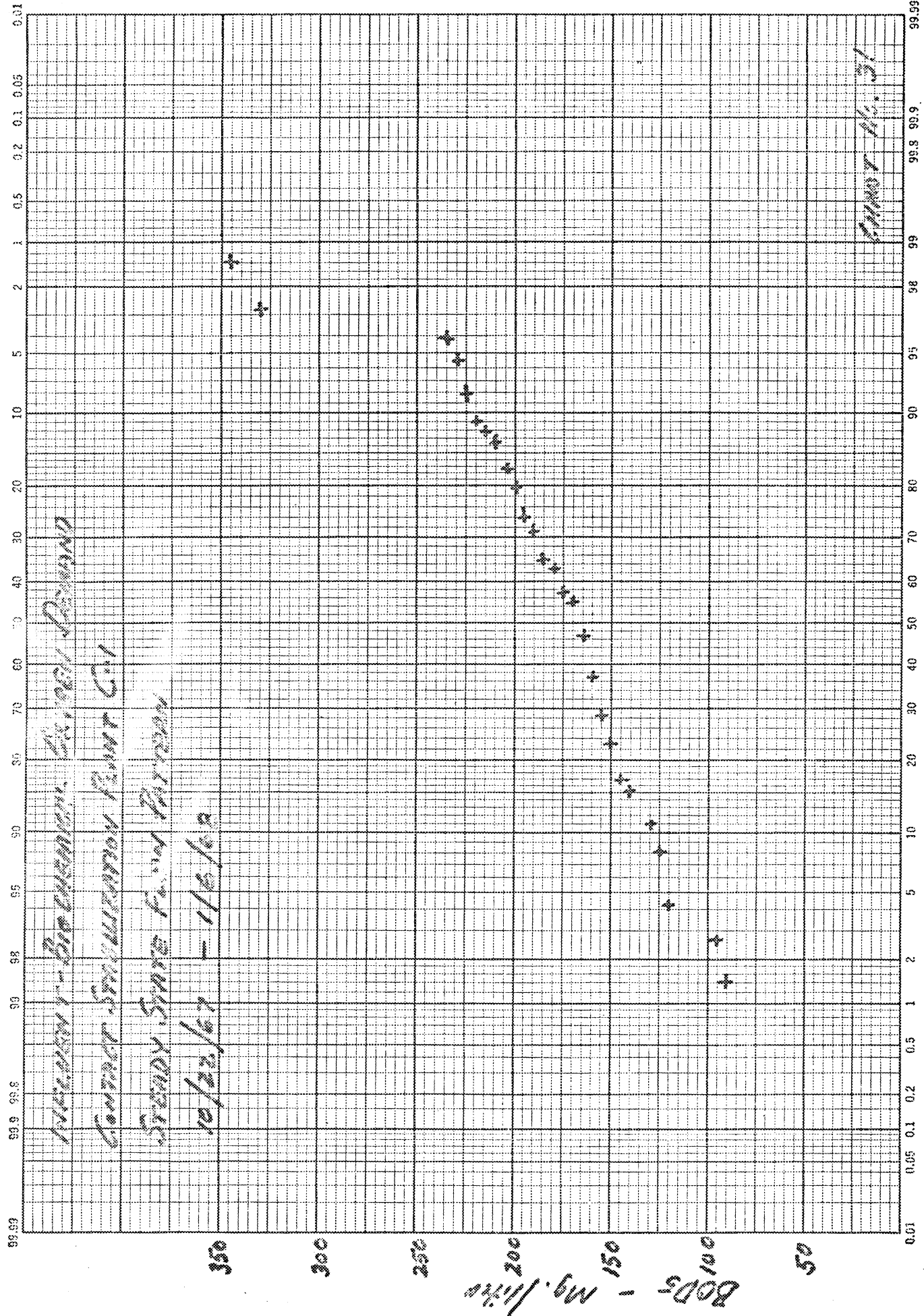
Chart No. 28

PERCENT OF VALUES EQUAL TO OR LESS THAN

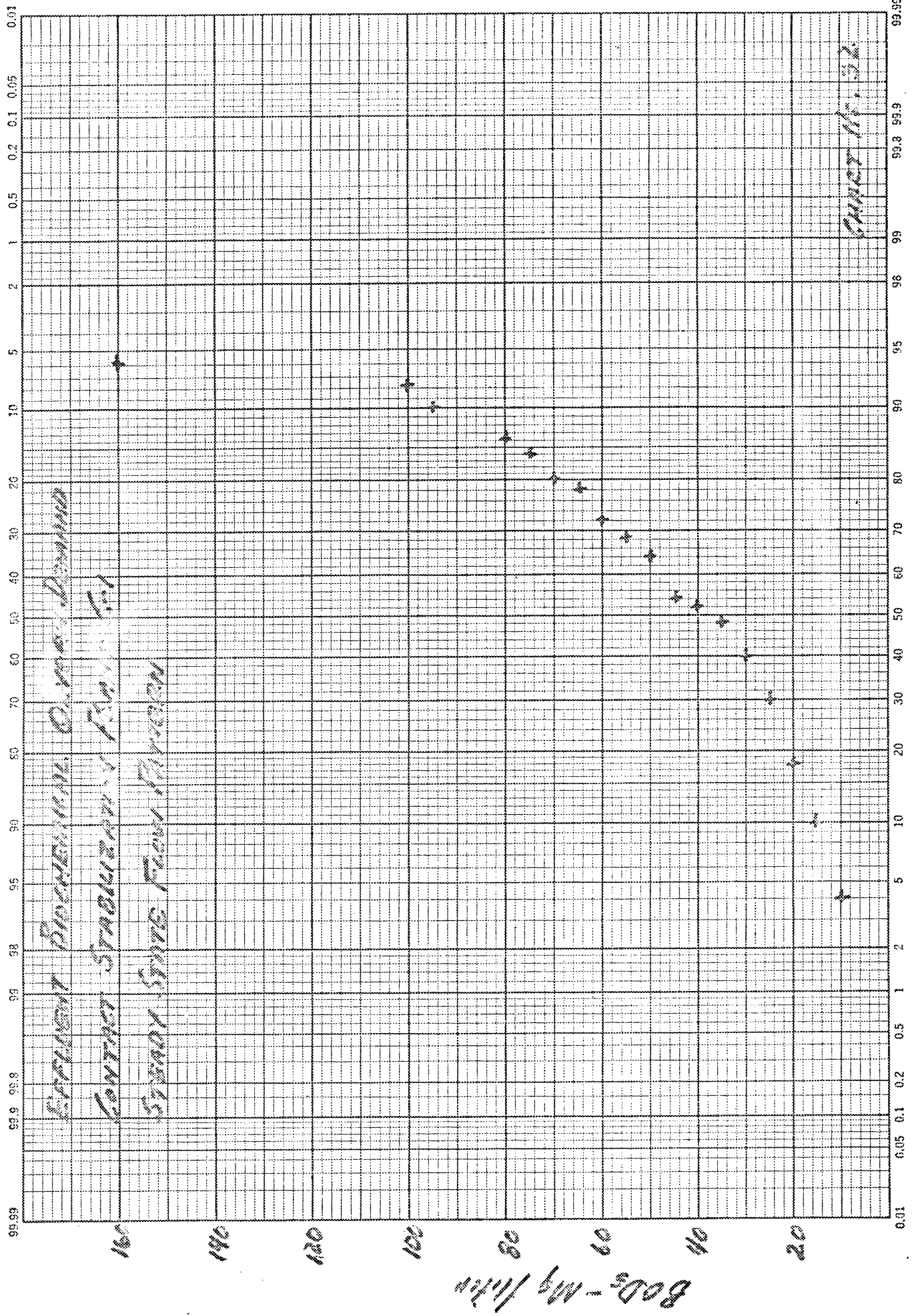
Suspended Solids - mg/lit



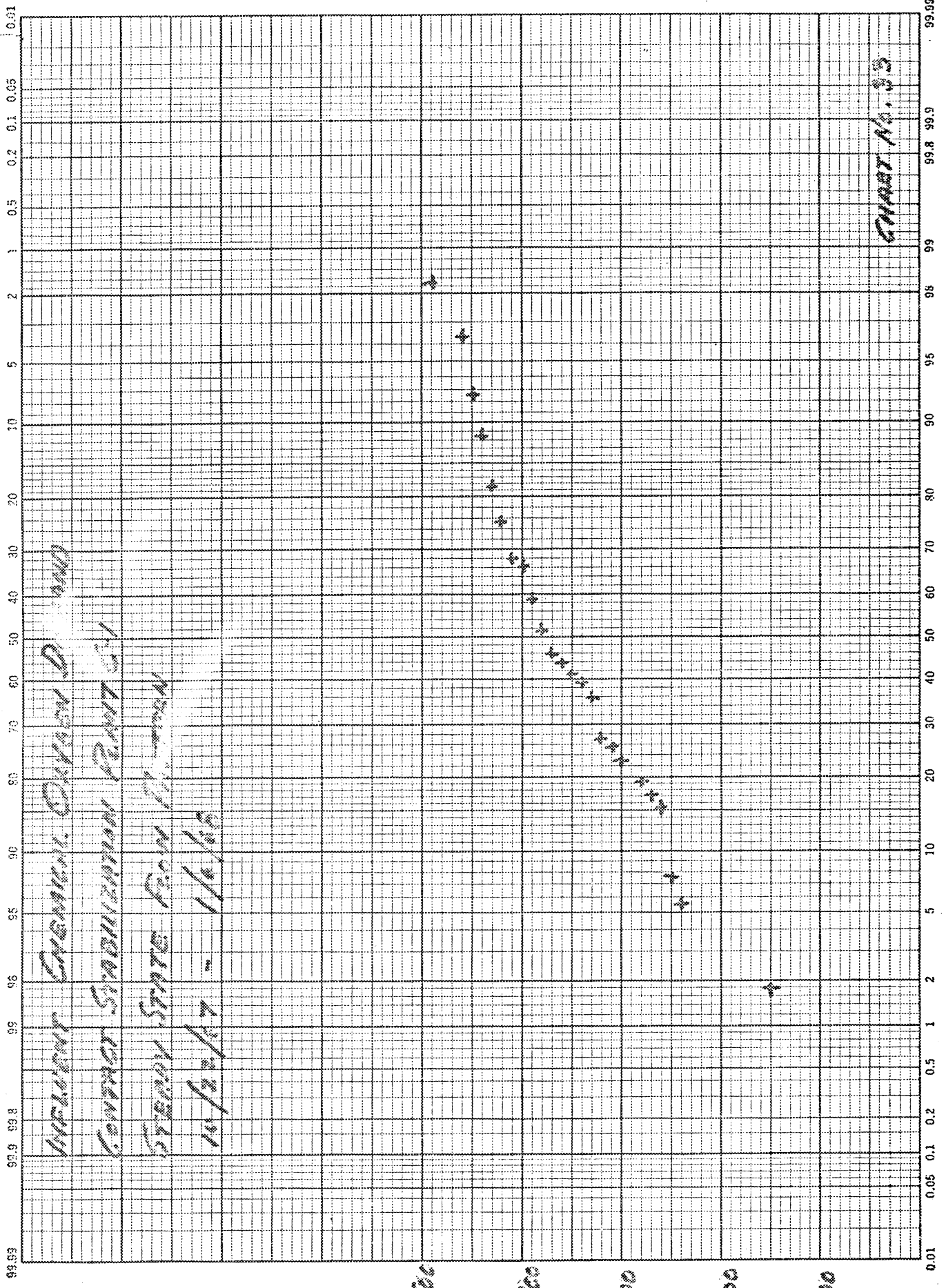
Percent of Values Equal to or Less Than



PERCENT OF VALUES EQUAL TO OR LESS THAN



... .. - 11:00 P.M. TH 10 / MAY - 1952

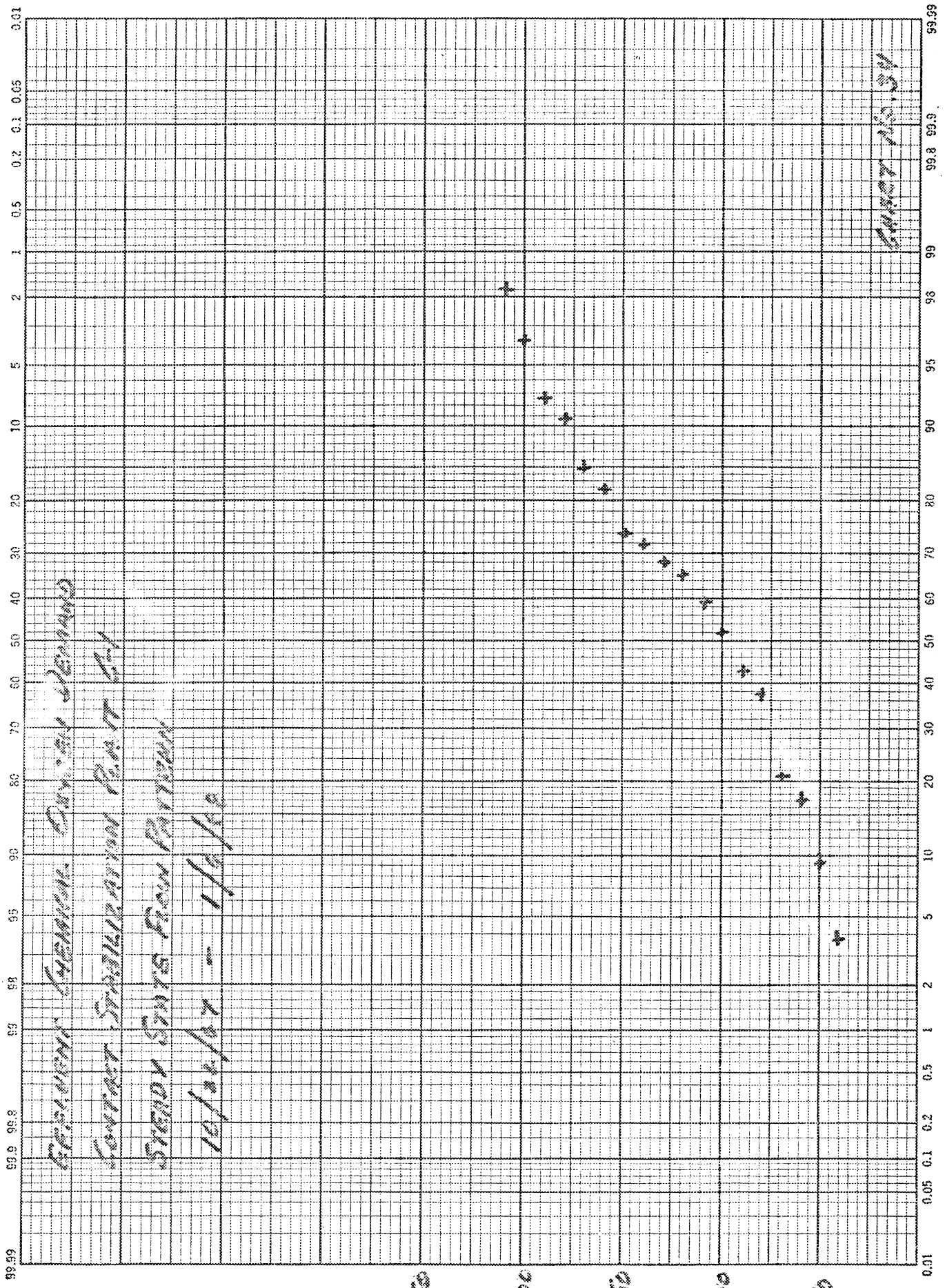


INFILTRATION CHEMICAL DIVISION  
 CONTRACT STABILIZATION PLANT #1  
 STONEY STATE FARM  
 11/22/67 - 1/1/68

CHART NO. 33

500  
 100  
 200  
 300  
 400  
 500

Drawn on this basis from the above data



EQUIPMENT SPECIFICATIONS DIVISION  
 CONTACT INFORMATION PART 11  
 STENOGRAPHY FROM PART 11  
 10/10/10

200  
 100  
 50

GUNNEY 11.1.34

Probability - a measure of chance

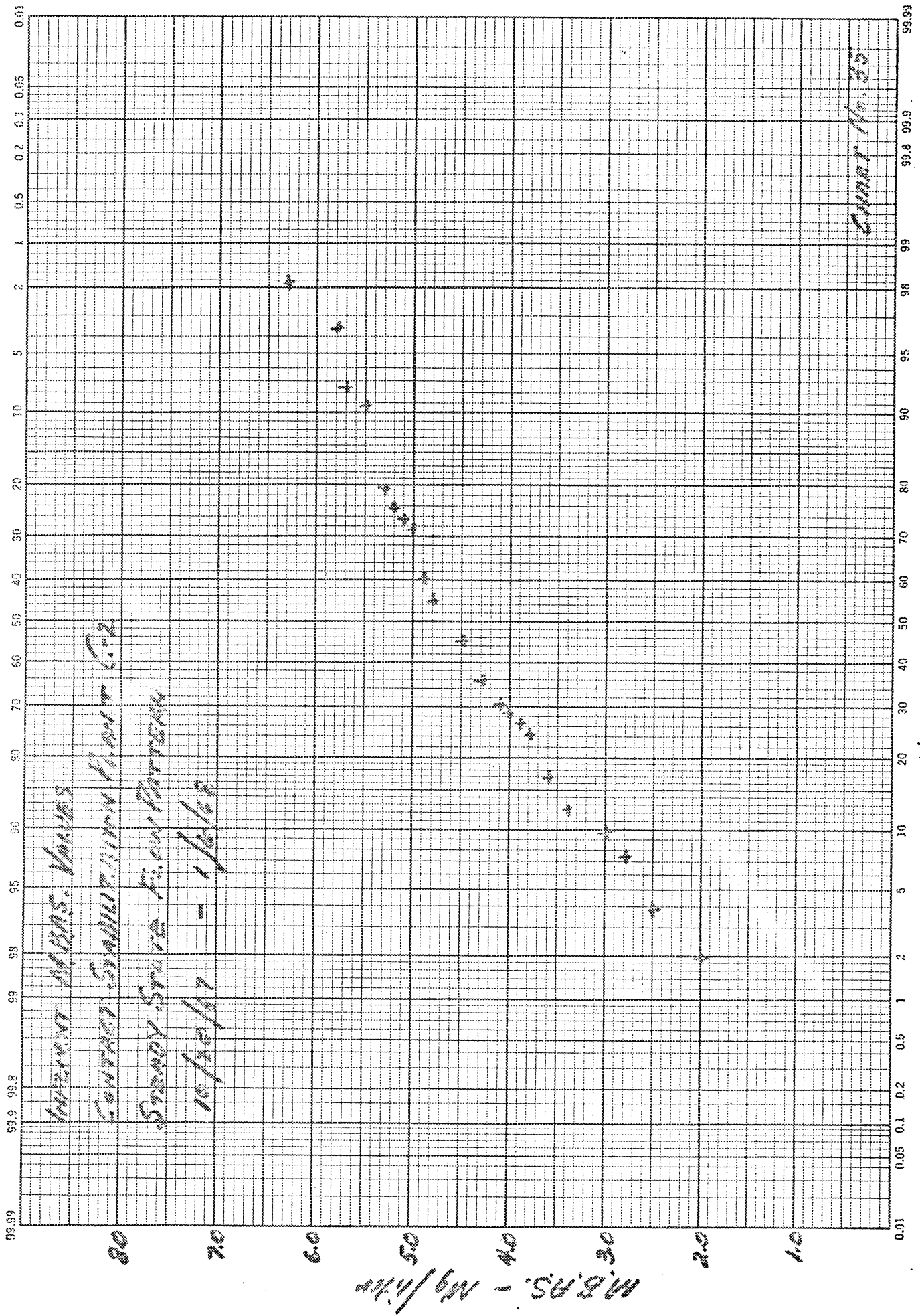
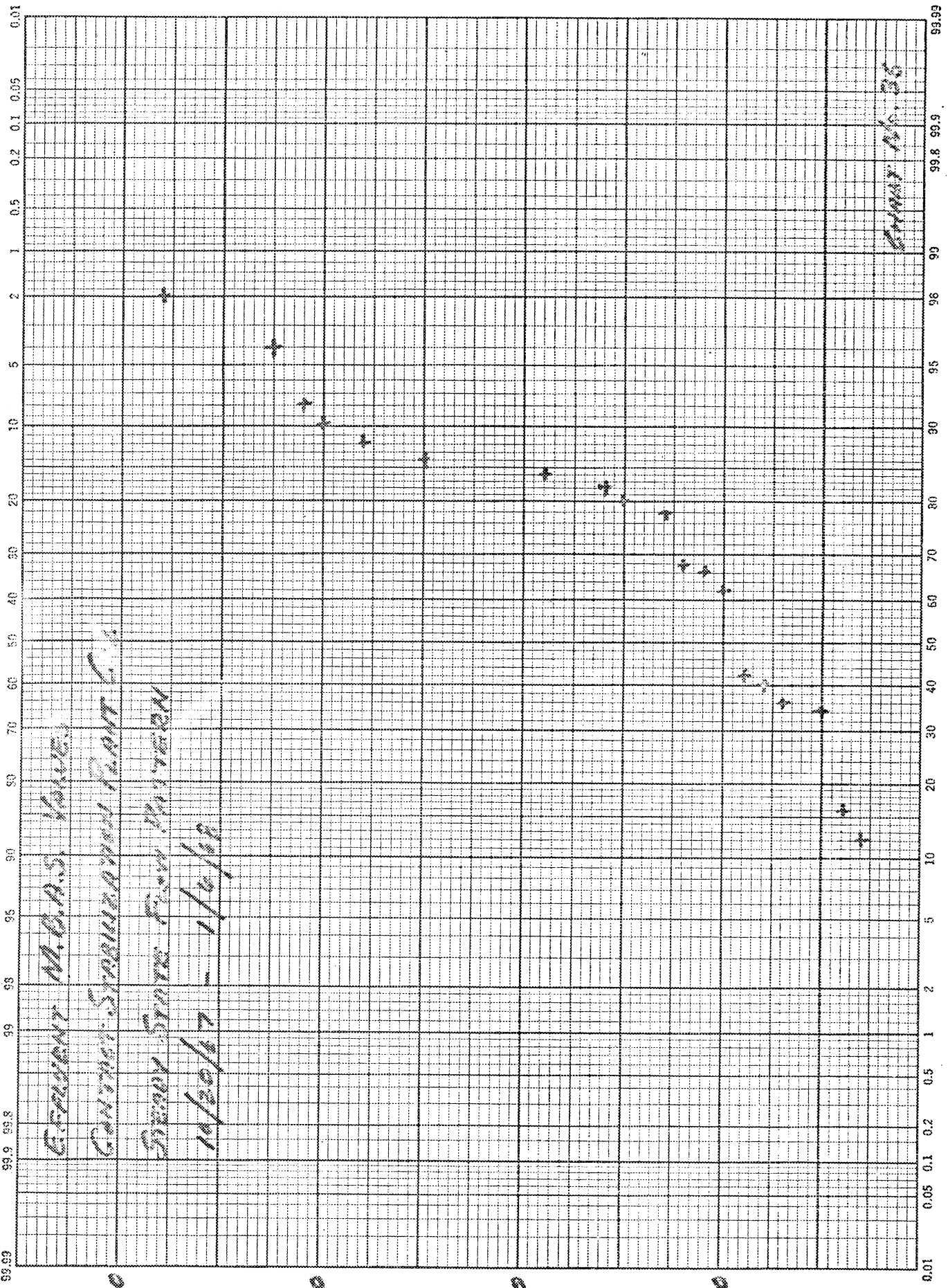


CHART No. 33





Percentage of Moisture Loss in an Iron Ore

40

3.0

M.B.S. VALUE

M.B.S. VALUE

1.0

0.01

0.05

0.1

0.2

0.5

1

2

5

10

20

30

40

50

60

70

80

90

95

98

99

99.8

99.9

99.99

99.99

99.99

99.99

99.99

99.99

99.99

99.99

99.99

99.99

99.99

99.99

99.99

99.99

99.99

99.99

99.99

99.99

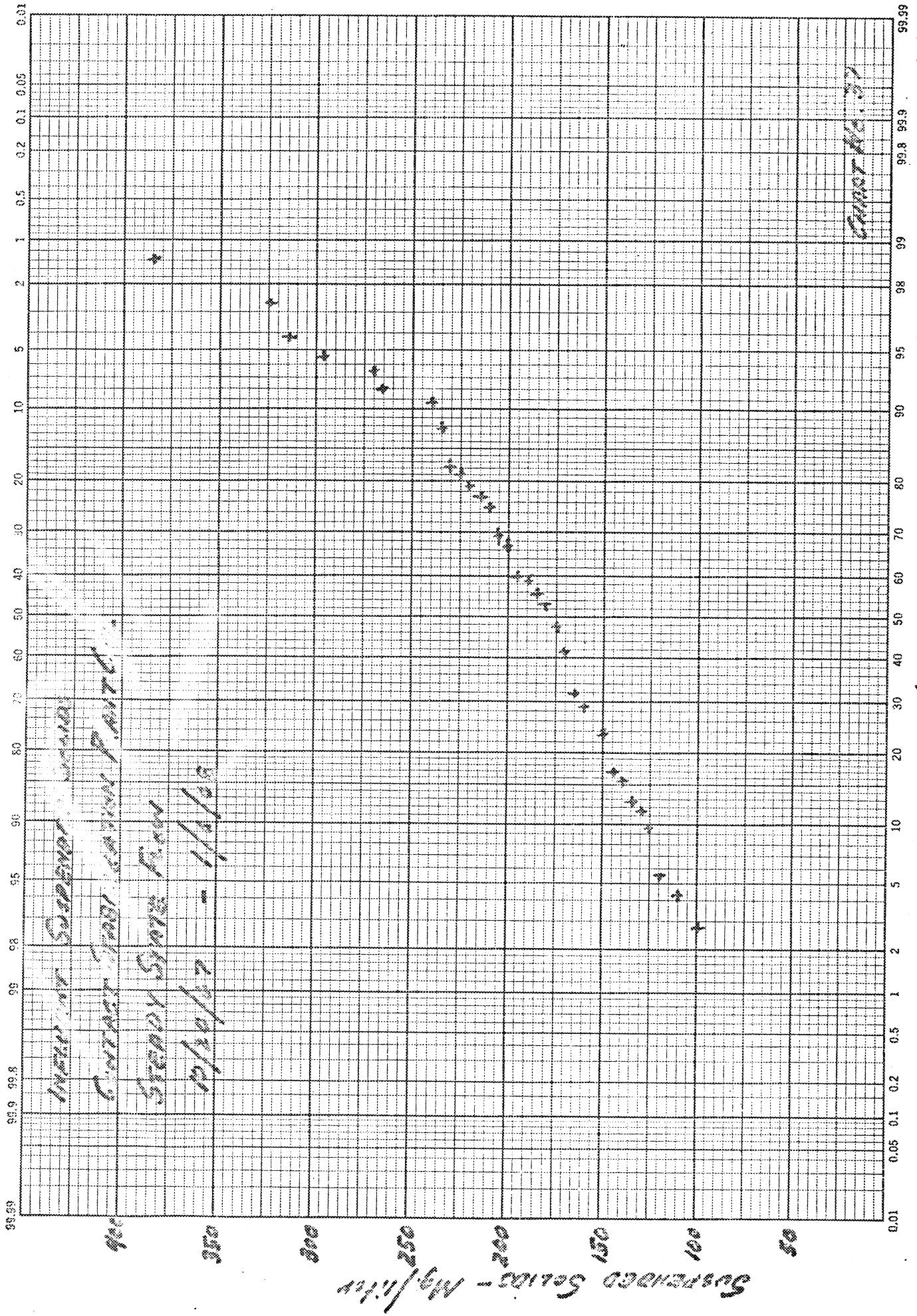
99.99

99.99

99.99

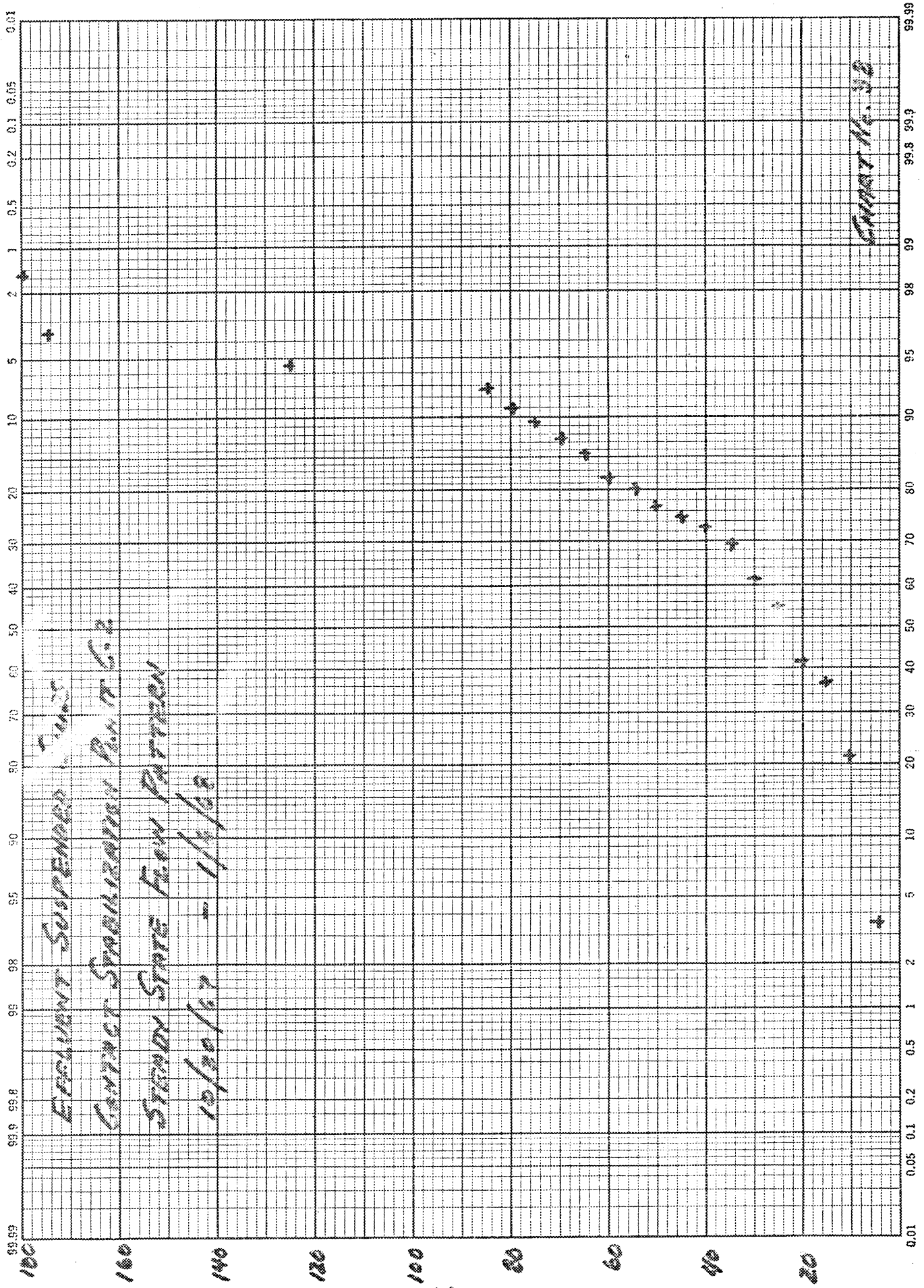
99.99

99.99

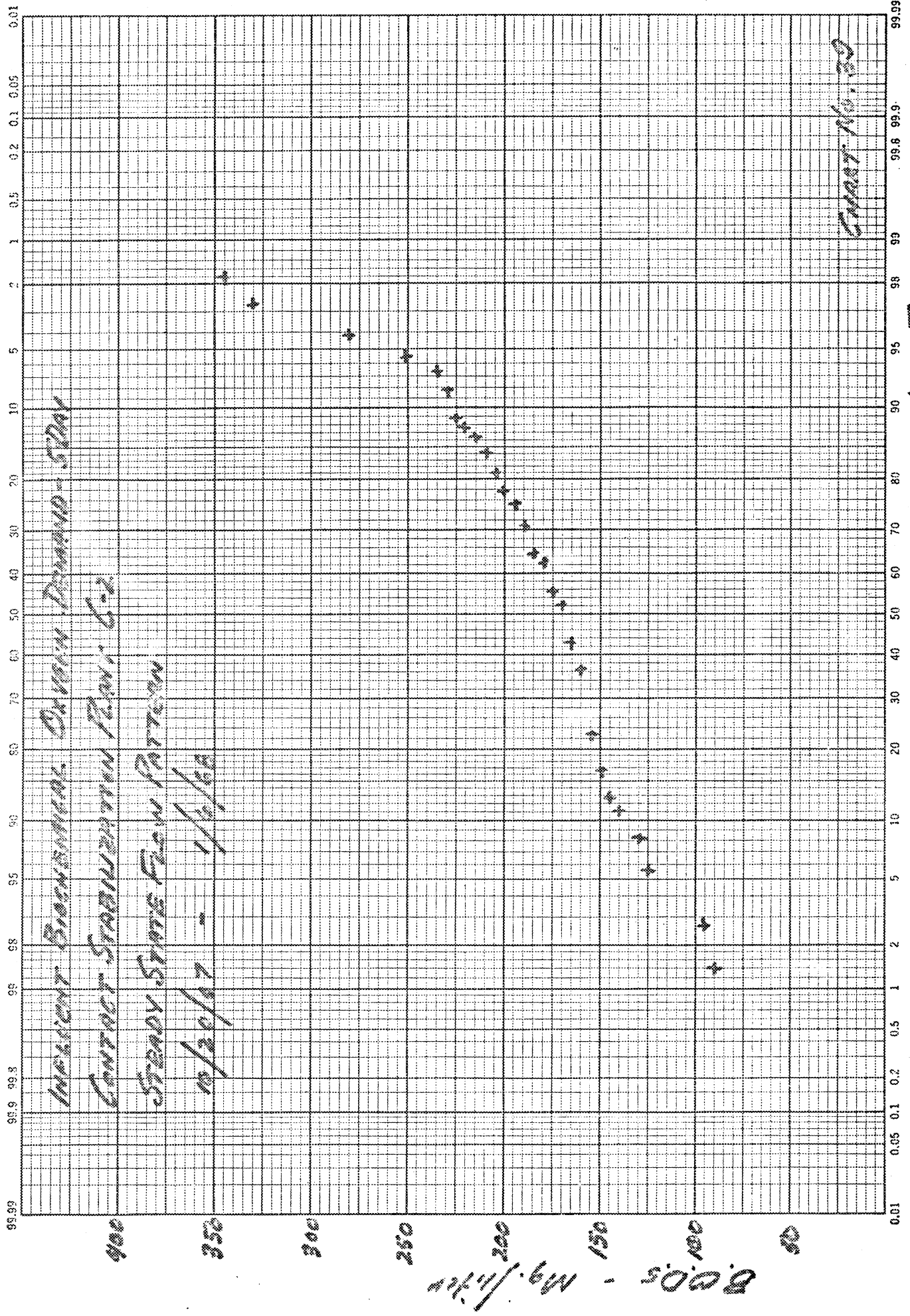


Percent of Values Equal to or Less Than

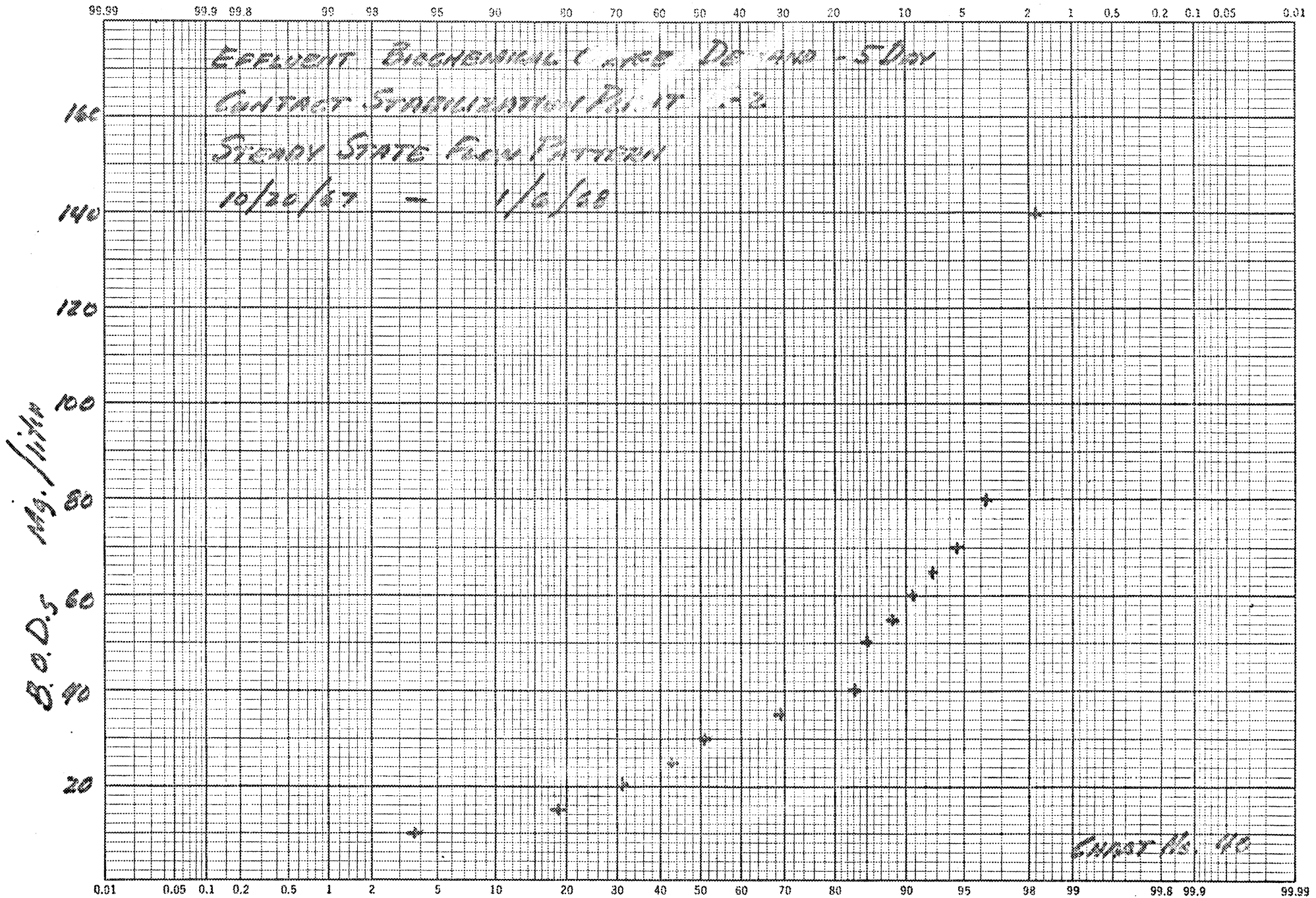
Suspended Solids - Mg./lit

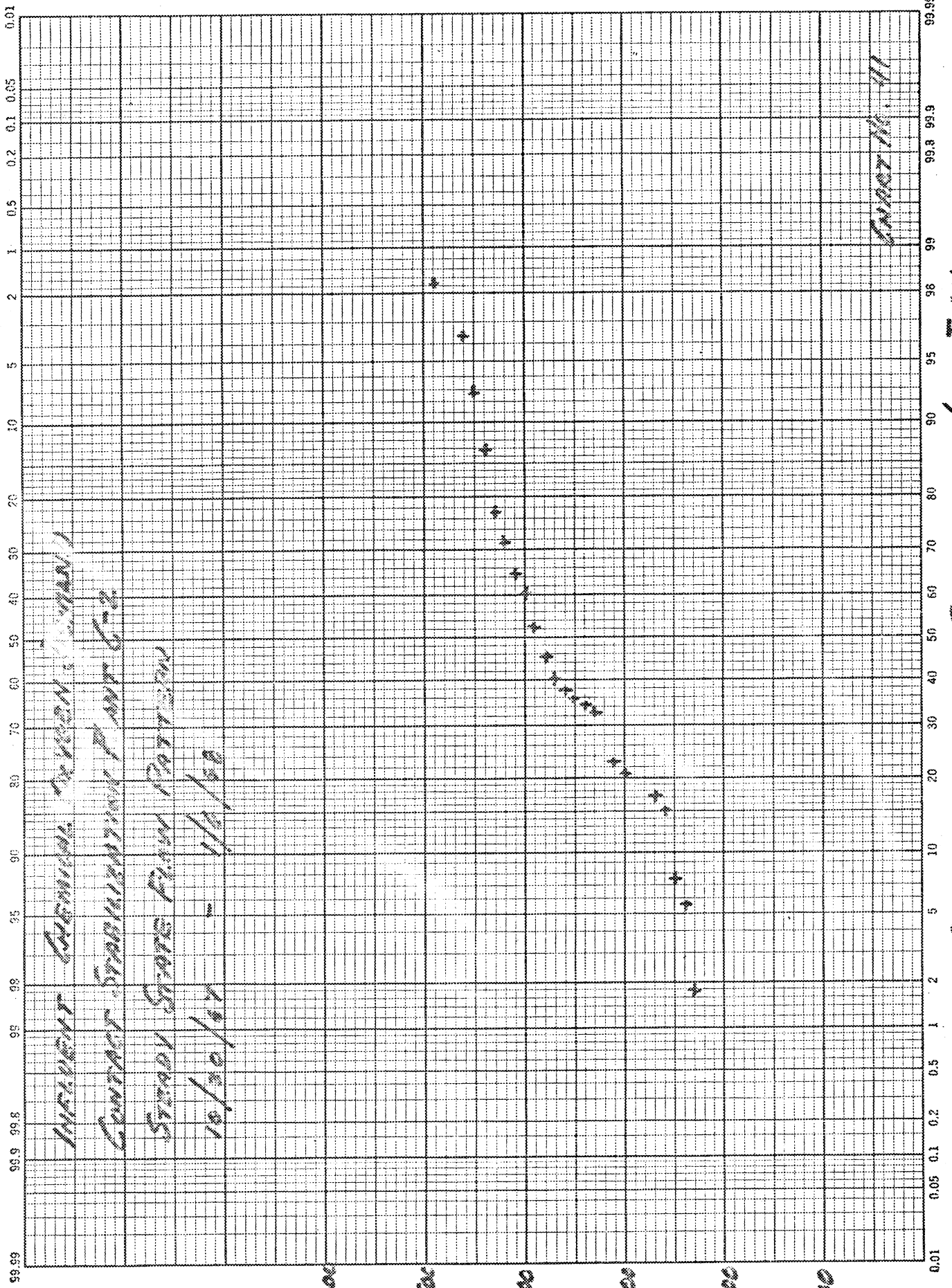


Percent or Values Equal to or Less Than



DRY. DRY. STAY  
 CONTRACT STABILIZATION PLAN: 6-2  
 STEADY STATE FLOW PATTERN  
 10/20/97 - 1/6/98





INFLUENT CONCENTRATION (Mg./LIT.)  
 CENTRAL STATIONARY POINT P.M. 6-2  
 STEADY STATE FROM PATTERSON  
 10/20/67 - 1/1/68

TABLE III

D - ... 10.000 ... 7% ... 1000 ... THAN

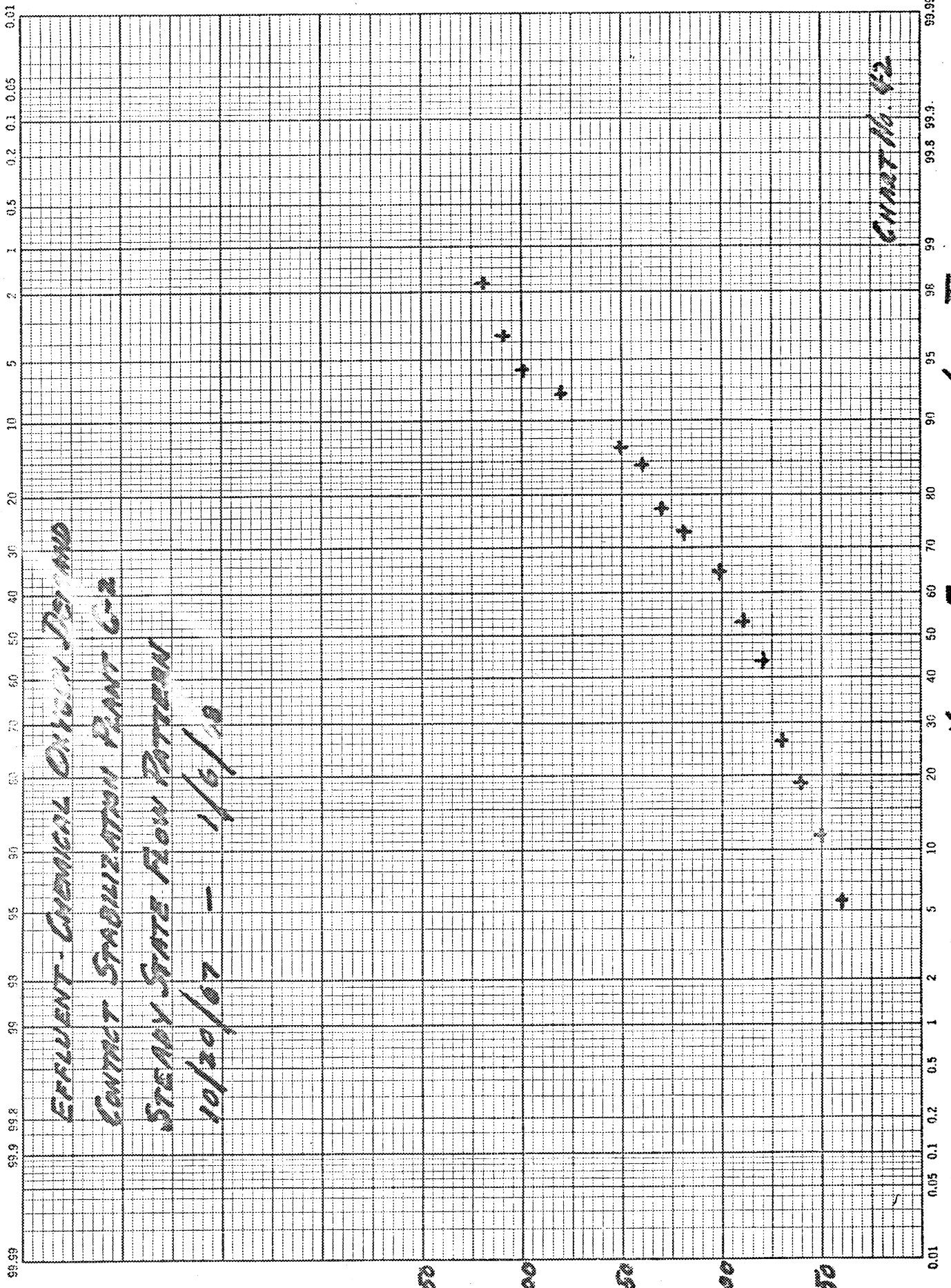


CHART 111-112

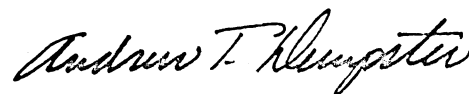
D... - Massie En... as per Test

reduction of MBAS but at very low rates as was demonstrated in the pipe loop "die-away" studies. The contact stabilization process as well as the extended aeration process of waste water treatment can reduce the MBAS content, but the data from the two types of plants would favor the extended aeration process. Phosphates are reduced in both types of package plants, but supplementary chemical treatment is indicated if phosphate removals of approximately ninety percent are required.

#### V. ACKNOWLEDGEMENT

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Submitted by:



Andrew T. Dempster  
Project Director  
National Sanitation Foundation

April 26, 1968