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PROGRESS REPORT FOR JANUARY AND FEBRUARY

on

# DEVELOPMENT OF TEST UNIT FOR PRODUCTION OF OXYGEN BY A REGENERATIVE CHEMICAL







Arthur D. Little, Inc.
CHEMISTS•ENGINEERS
CAMBRIDGE, MASS.

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Progress Report for January and February on Development of Test Unit for Production of Oxygen by a Regenerative Chemical

Work on this project at A. D. Little, Inc. during January and February 1943 has been largely directed at arriving at ideal operating conditions for the shipboard unit. Two factors have been primarily considered: first, a cycle to produce high hourly yields and long life and second the effect of air quality especially moisture and oil on the life of the compound.

These tests were made using a cycle producing 15 lbs. of oxygen per hour per 100 lbs. of powder. Desorption pressure was at an average value of 10 inches of mercury absolute. Loss in capacity has been the lowest for any method of operation tested to date.

The use of undried air from an oil sealed compressor has given longer life for Rumford High-High Salcomine than silica gel dried air or silica-gel dried and charcoal purified air from the same compressor.

The above test is currently continuing with the desorption pressure raised to 15 inches mercury pressure absolute.

Some further work has been done on Ethomine using the same powder loading employed for the life tests described in our December report. The cooling water temperature was reduced from 104°F. to 50°F. The rate of absorption increased and the rate of deterioration decreased. The increase in absorption rate does not check the work of the group at M.I.T. in a different apparatus. There was considerable difference however in the extent of degradation of the Ethomine used by the two groups which might have affected the results of the tests. The studies on cooling water temperature will continue as other features of our program permit.

A small single-case medical unit employing Ethomine as the absorbent has been tested. This unit was based on the use of a Yoemans Bros. rotary compressor. This pump served on part of the cycle as a blower to feed air to the unit and as an evacuator on part of the cycle to permit vacuum desorption of the bed.

Mechanical difficulties have been encountered which have prevented the satisfactory operation of the unit. A more detailed description of the unit will be given in a future report.

Construction has been completed on a small testing unit for determining the absorption and desorption characteristics of small samples of regenerative chemicals. This unit consisting of a thermostatically controlled powder holder, a dropping mercury gas circulating pump and an oxygen reservoir system has not been tested at this report writing. Complete details on this unit and its operation will be given in an early report.

## Body of the Report

In connection with the design of the shipboard unit the group at Arthur D. Little, Inc. has been asked to study the effects of air quality and to work out a suitable cycle for the unit.

The problem of air quality centers around two main points namely; the effect of moisture in the air fed to the beds and the effect of oil mist in the air arising from the use of oil sealed compressors. This is important as far as the shipboard unit is concerned since if it is found that moisture, oil or both are not detrimental to the life and performance of Salcomine as it is proposed to use it in the unit, a considerable amount of drier and air purifier equipment can be eliminated

Our studies of a cycle to use with shipboard unit have been along the lines suggested by the work discussed in our December report on the effects of cycle changes. That work all pointed to long life when hourly production was at its highest level. In other words the periods of non-absorption or desorption were kept at a minimum. That high production and long life should go hand in hand is most fortunate since this permits the design of a unit of minimum size and with excellent life and production capacity.

Further increase in the hourly productivity of the flat bed units beyond that obtained with 5 1/2 min. absorption, 1/2 min. vent and 2 min. desorption cycle appeared impossible due to the lack of lower temperature cooling water for absorption.

This cycle therefore has been continued and present use of it serves as a check on the excellent life curve obtained with it during its first period of use.

The results are given in plots I, II, III, IV, V, VI and VII. In plot I is found the saturation and productivity degradation curves. In plot VI is shown the saturation degradation curves plus that calculated from the data obtained during the first use of this short cycle. Interestingly enough the more carefully the air is purified the more rapidly the powder loses its initial saturation capacity. This is the first time this has been reported.

In plots II and IV will be found the absorption curves obtained at various points during the above tests while on plots III and V will be found desorption curves at corresponding points in the life of the powder. These curves all show the fact that absorption and desorption periods are being advantageously used during their entirety. This is particularly true of absorption period where the rate changes comparatively little.

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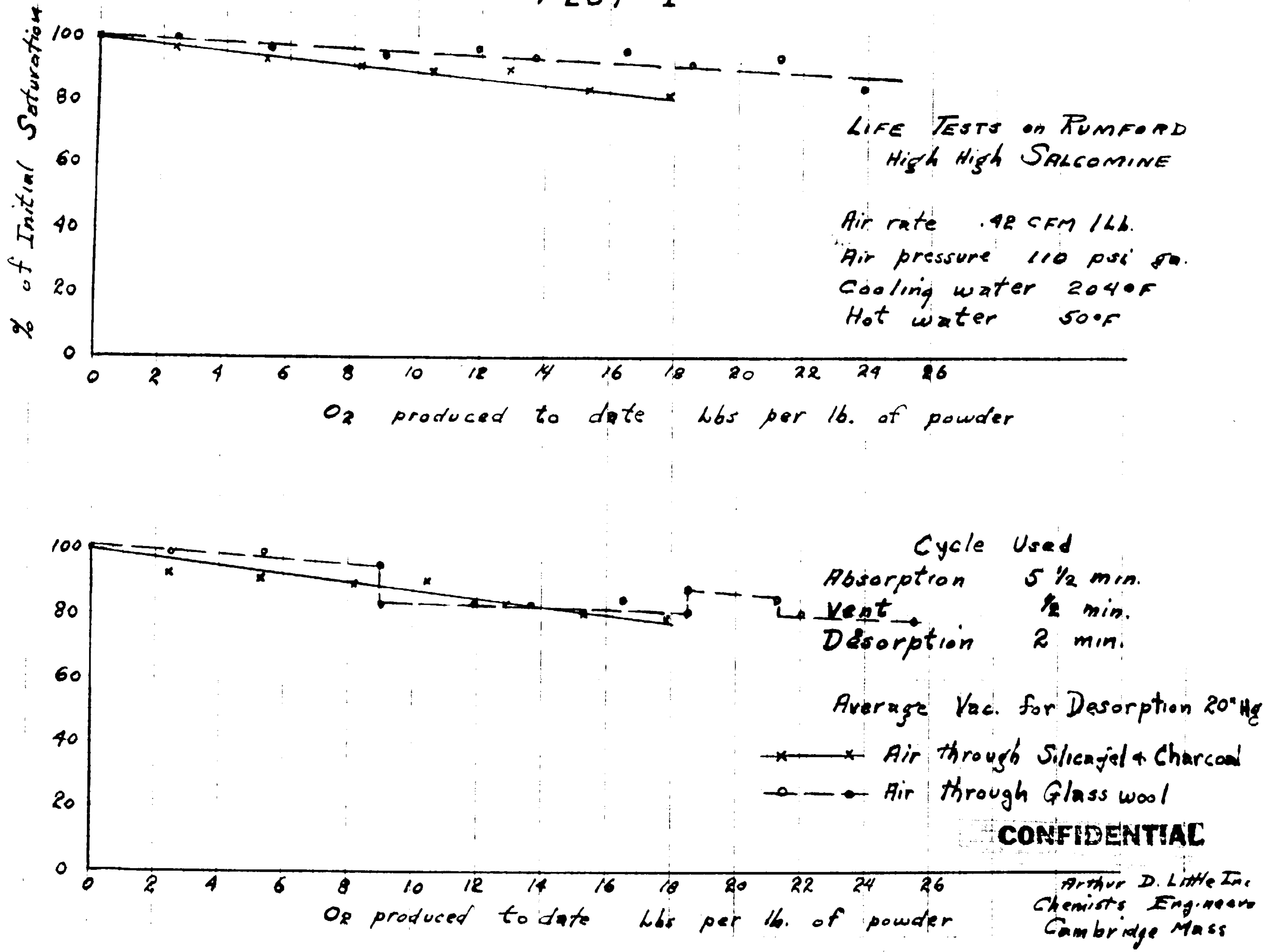
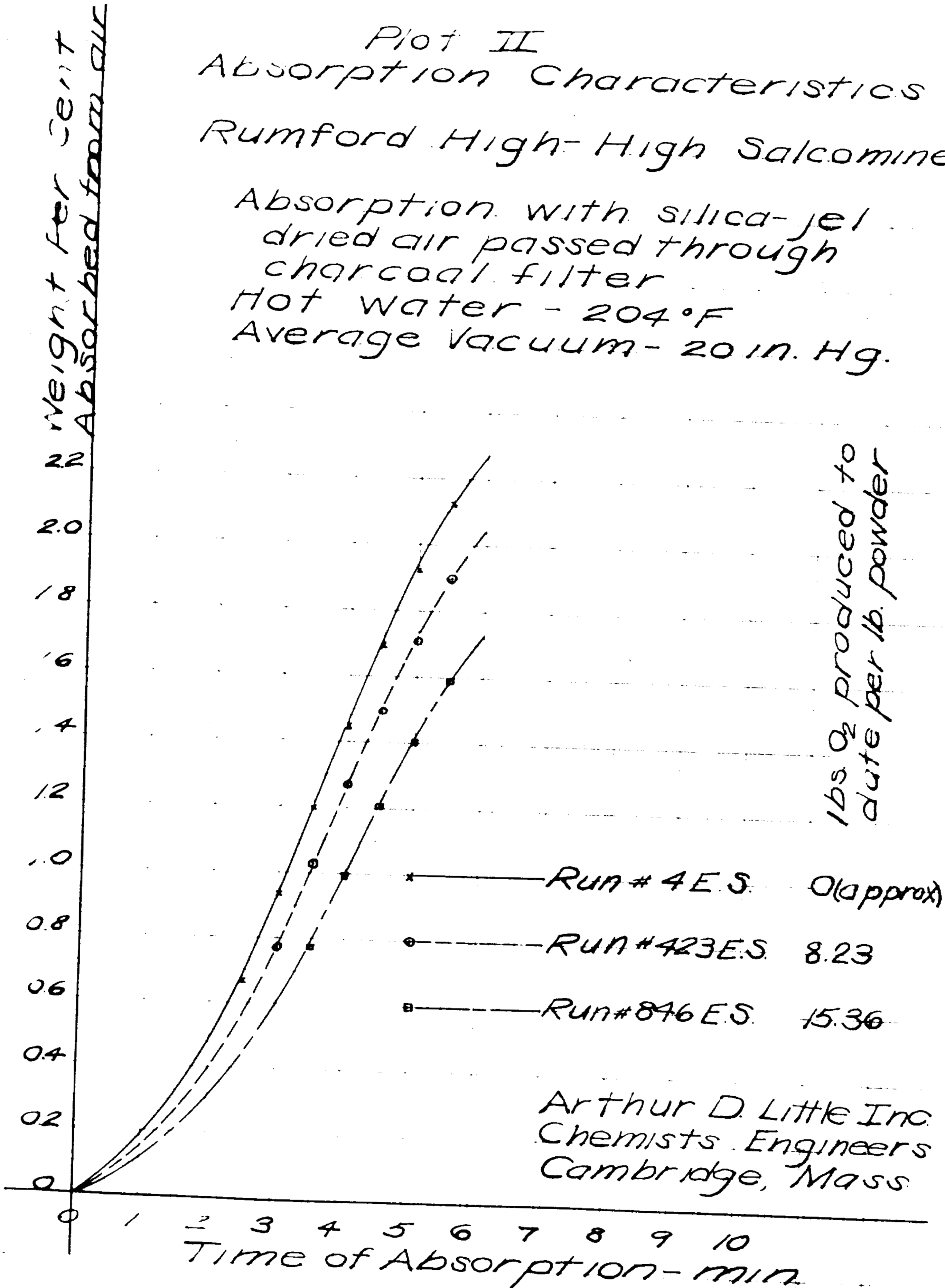
# PLOT I



## Plot II
## Absorption Characteristics

Rumford High-High Salcomine

Absorption with silica-jel dried air passed through charcoal filter
Hot Water - 204°F
Average Vacuum - 20 in. Hg.

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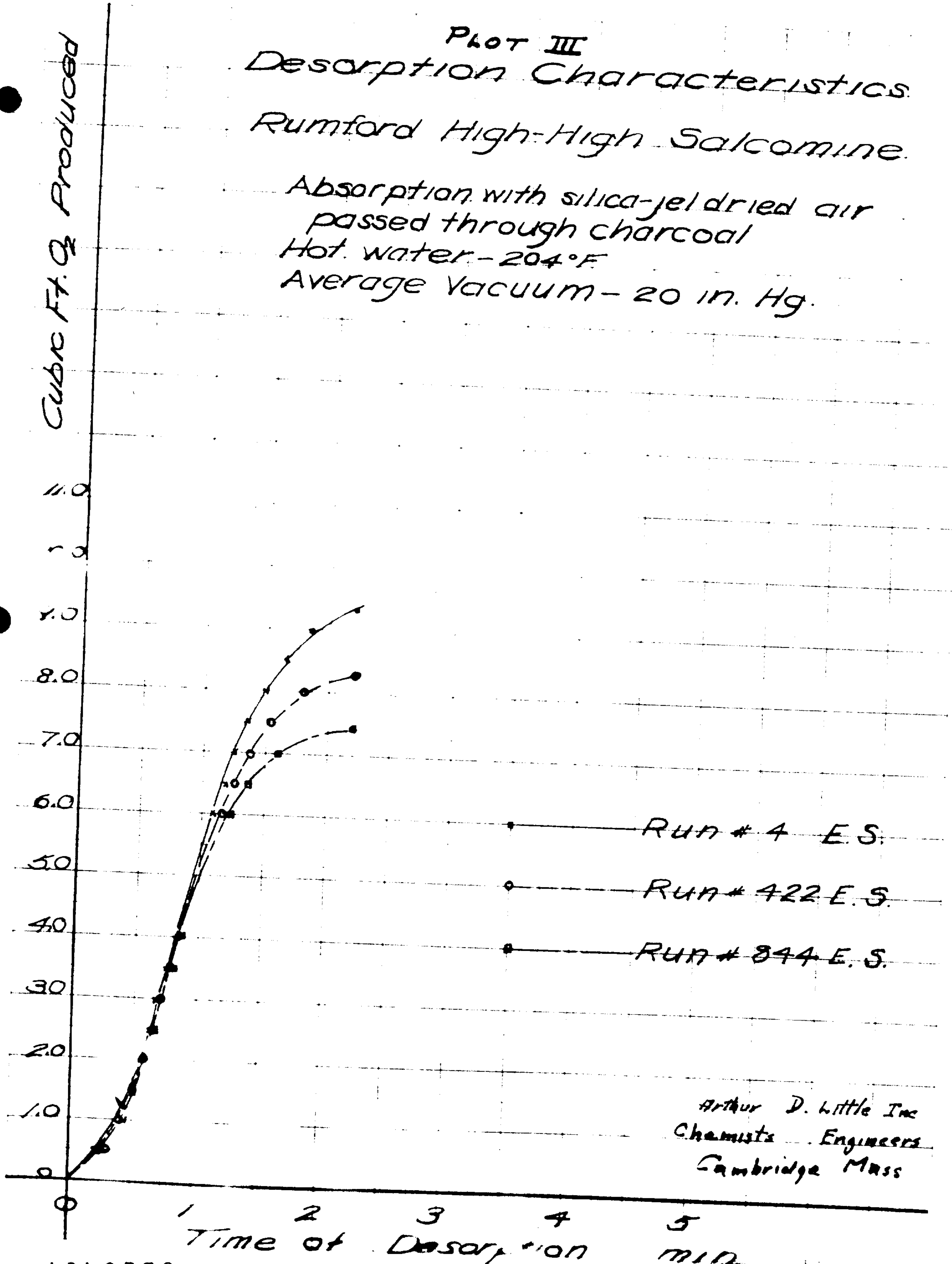
PLOT III
Desorption Characteristics
Rumford High-High Salcomine
Absorption with silica-jel dried air
passed through charcoal
Hot water - 204°F
Average Vacuum - 20 in. Hg.
Cubic Ft. O2 Produced
11.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
0
1
2
3
4
5
Time of Desorption min
Run # 4 E.S.
Run # 422 E.S.
Run # 844 E.S.
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Chemists Engineers
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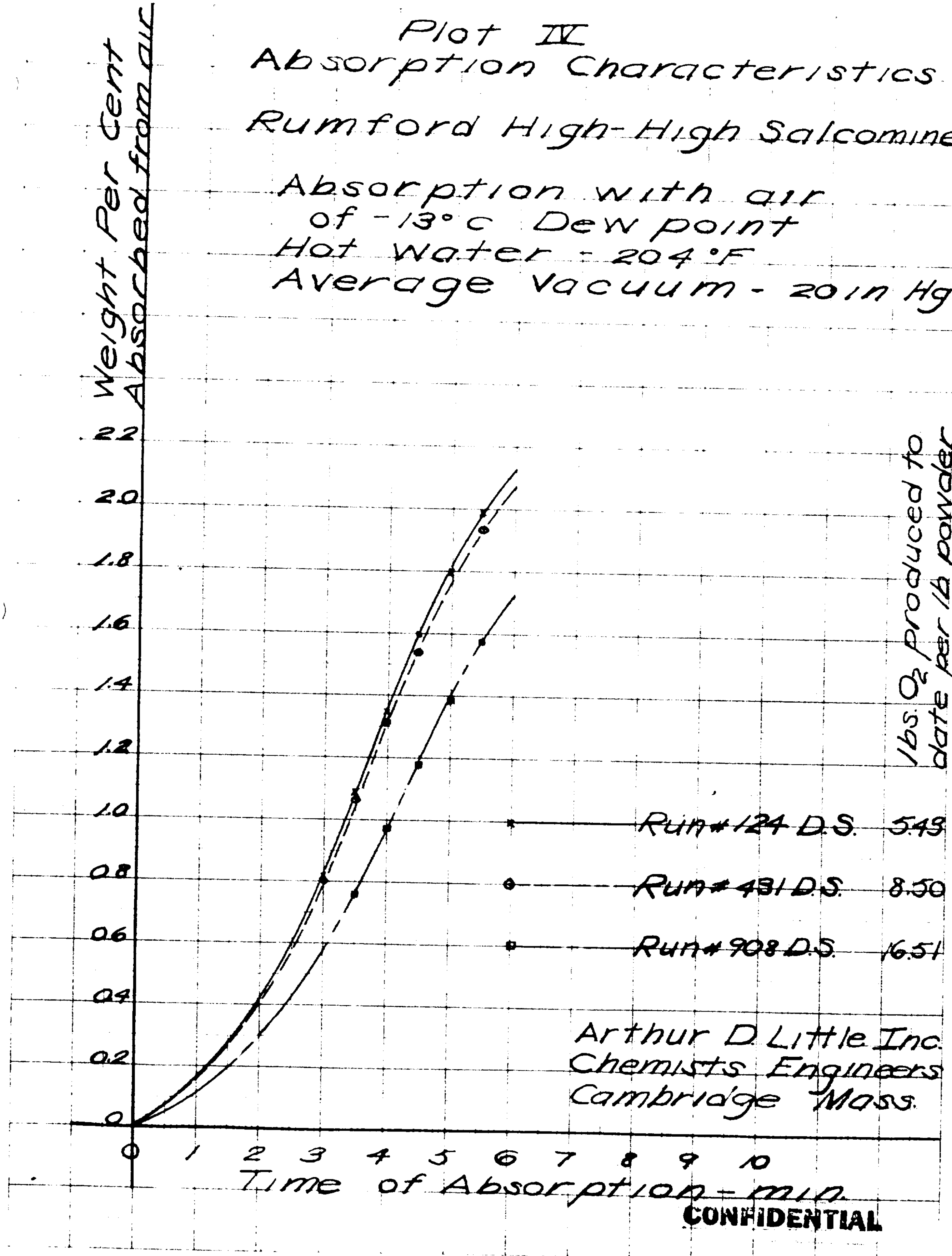


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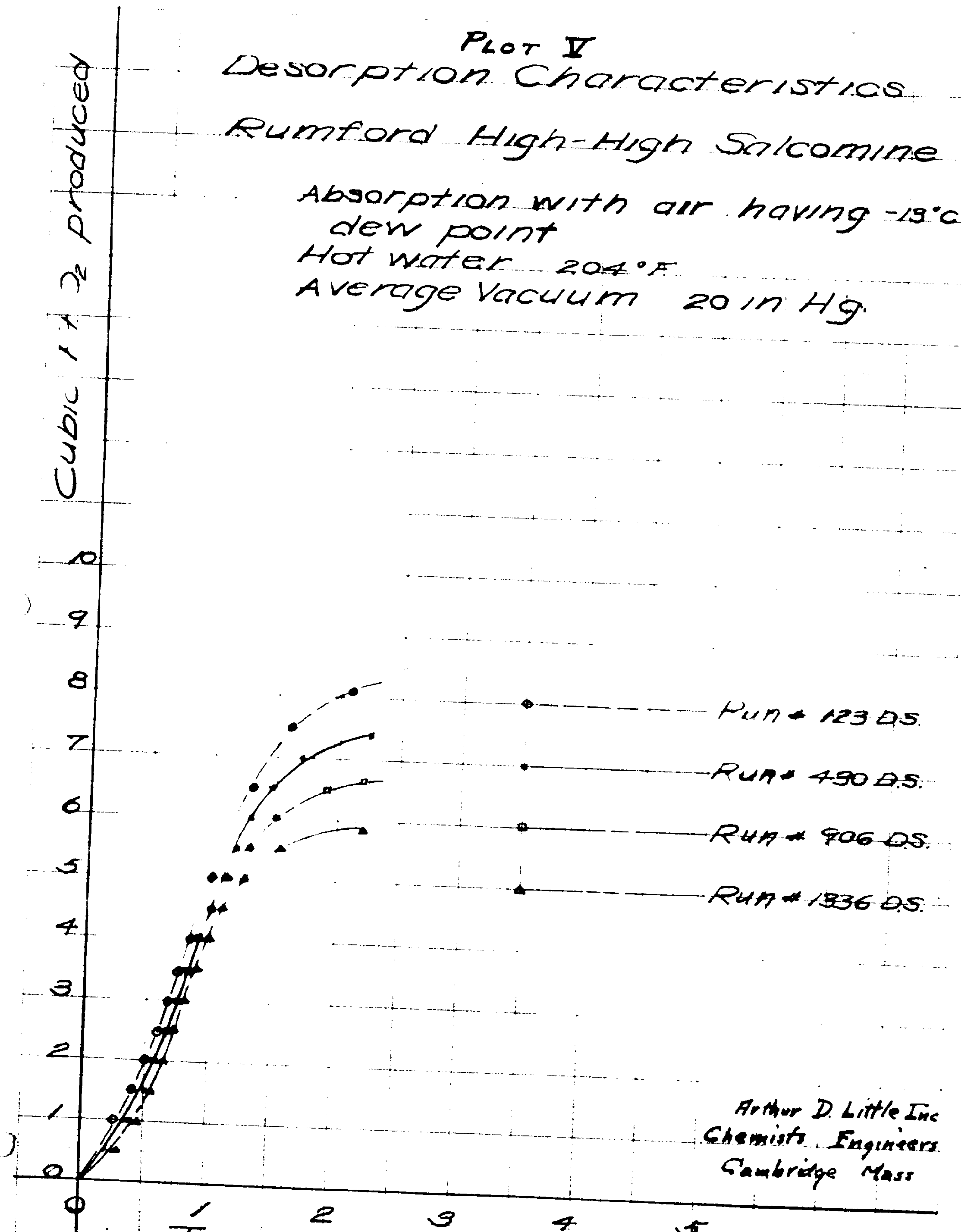


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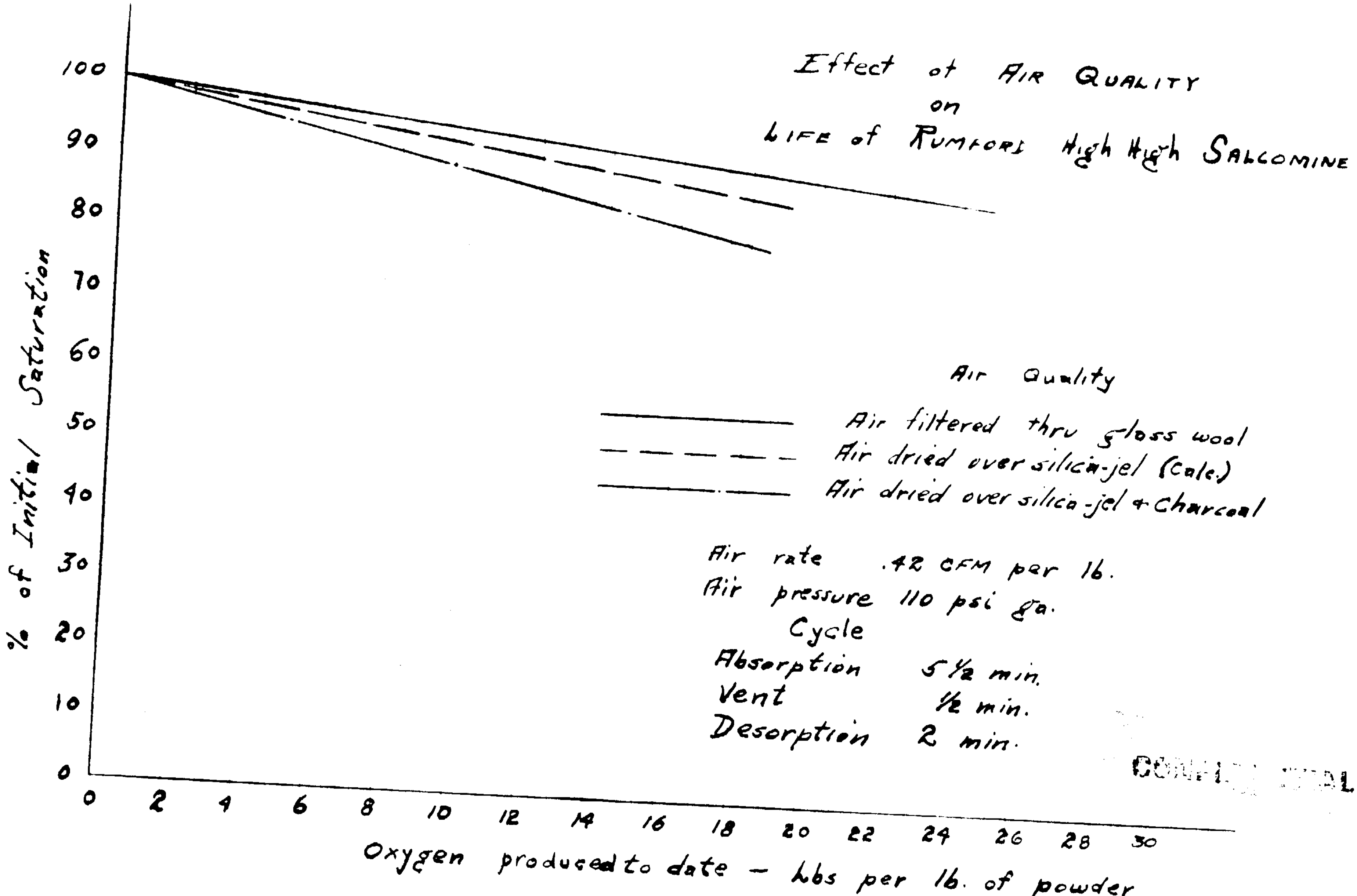
# PLOT VI



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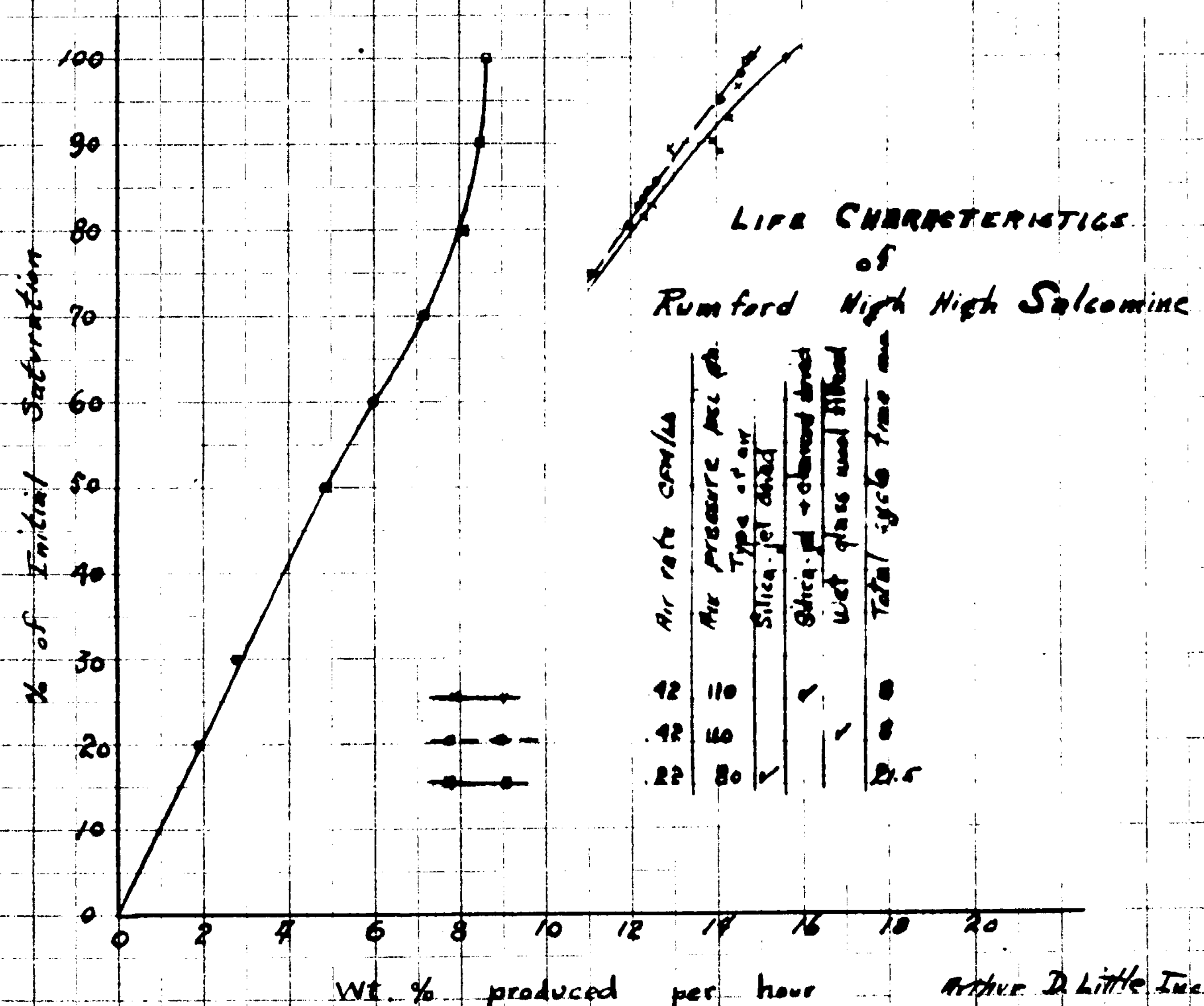
# PLOT VII

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It should be pointed out that the initial saturation and productivity levels were slightly different for the two methods of operating. The case using wet air gave initially lower values. However, since loss in saturation and production capacity were less with the use of wet air it is felt that the initial difference was due to a difference in the lots of powder used to fill the two powder beds.

In the bed using wet air, powder received in November of 1942 was used while in the other bed with dry air, powder received in February of 1943 was used. It is interesting to note that the older powder, while stored in air tight containers, shows the lower initial capacity.

Plot VII has been prepared to show the dependency of degradation on hourly production. It is seen that when the units are so operated to take full advantage of their heat transfer capabilities that hourly production is a direct function of the % of initial saturation. This is shown in the two portions of curves where an air rate of 0.42 CFM per pound of powder and an air pressure of 110 psi. ga. were used.

In the unit operating below the maximum heat transfer level, saturation falls off markedly with but slight change in production until the capacity has fallen off considerably. Then heat transfer becomes limiting and the straight line relationship mentioned above applies.

The peculiar effect of moisture on the life of the powder invites speculation as to the significance of the data.

The first question that arises is whether the data truly represents the actual facts. Can these tests be duplicated? Available equipment does not permit starting up two new units on a duplicate test. No duplicate tests have been made in the past on the scale being carried out here. The M.I.T. group do not feel they can get check life curves to agree much closer than those under consideration. Therefore at present we are unable to say for certain that unpurified air does actually give increased life. All that can be said is that the present test definitely indicates such increased life.

Assuming the data to truly represent the facts, one possible explanation is that when highly dried and purified air is used the Salcomine becomes dehydrated beyond the point of maximum capacity and activity.

It seems possible that this phenomenon might appoar in the cases under test and not in equipment used by others. The better heat transfer characteristics of these cases might well tend to over dry the beds at the end of the desorption removing water of hydration which would be regained during absorption when wet air was employed.

In plot I it will be noted that when undried and unpurified air was used that the productivity curve shifted between what appear to be two separate curves. An explanation has been sought for this behavior and would seem to be the following.

In making the present series of tests the air supply proved inadequate to operate the two tests simultaneously. Therefore each case was operated 24 hours and then shut down while the other case operated for 24 hours.

Apparently some slight mechanical detail such as the extent a cold or hot water supply valve opened varied between two points causing the sharp rises and falls in the productivity. The fact that the saturation curve shows no such breaks indicates quite strongly that the powder was not the cause of these breaks in the production curve.

The tests on these cases are being continued at a higher absolute pressure. The Clark Bros. compressor to be used on the shipboard unit will take oxygen from the beds at 1/2 an atmosphere pressure. The present tests are therefore being made at an average desorption pressure of 15 inches absolute of mercury.

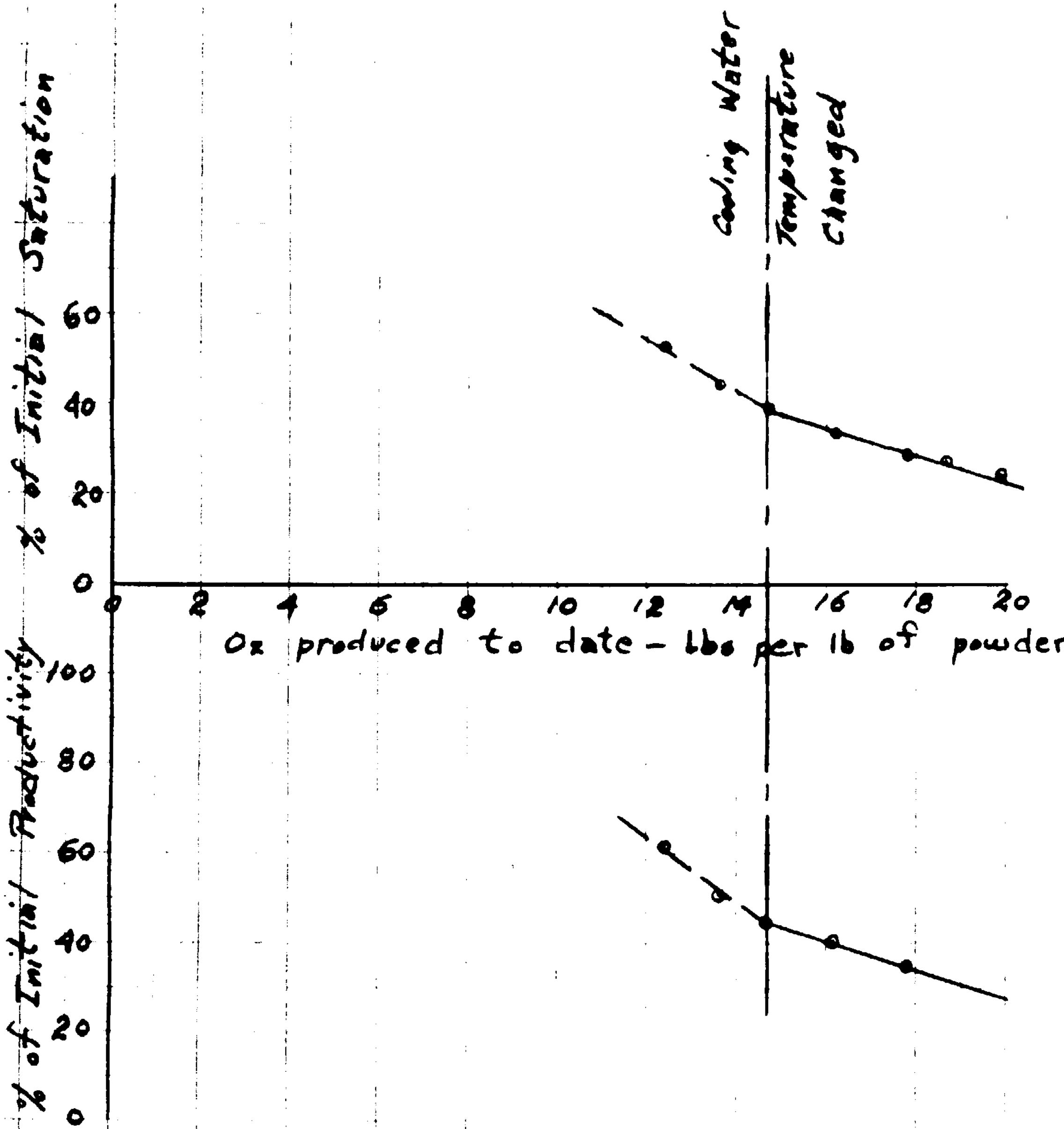
## Effect of Lower Temperature During Absorption When Using Ethomine

For some time it has been appreciated here that one determining factor in the matter of maximum utilization of an absorbent's capacity was the rate of heat removal from the powder during absorption. The heat transfer rate is dependent upon several factors, one of the chief ones being the temperature difference between the bed and cooling water. Plot X shows how the absorption rates vary for Salcomine used in our shallow bed with various temperatures of cooling water.

In connection with the development of a cycle to give the highest possible oxygen production per hour per pound of powder, the desirability of improving transfer rates by increasing this $\Delta$ T by decreasing the temperature of the coolant became apparent. In the case of Salcomine this meant using a refrigerated brine solution which was not possible with the equipment at hand.

To check the point it seemed far more desirable to work with Ethomine. Here an increase of 50°F. in the $\Delta$ T could easily be obtained without resort to refrigerated brine solutions. The results on the life test and the absorption rates are shown in plots VIII and IX.

# PLOT VIII




LIFE TEST on ETHOMINE
SHALLOW BED CASE

Air rate 0.6 CFM/lb
Air pressure 20 psi ga.
16" psi steam for desorption
Average vac. for desorption 20" Hg

Cycle
Absorption 5 min.
Vent 1 min.
Desorption 2 min.
Cooling 2 min

Cooling $H_2O$ Temp.
104°F
50°F

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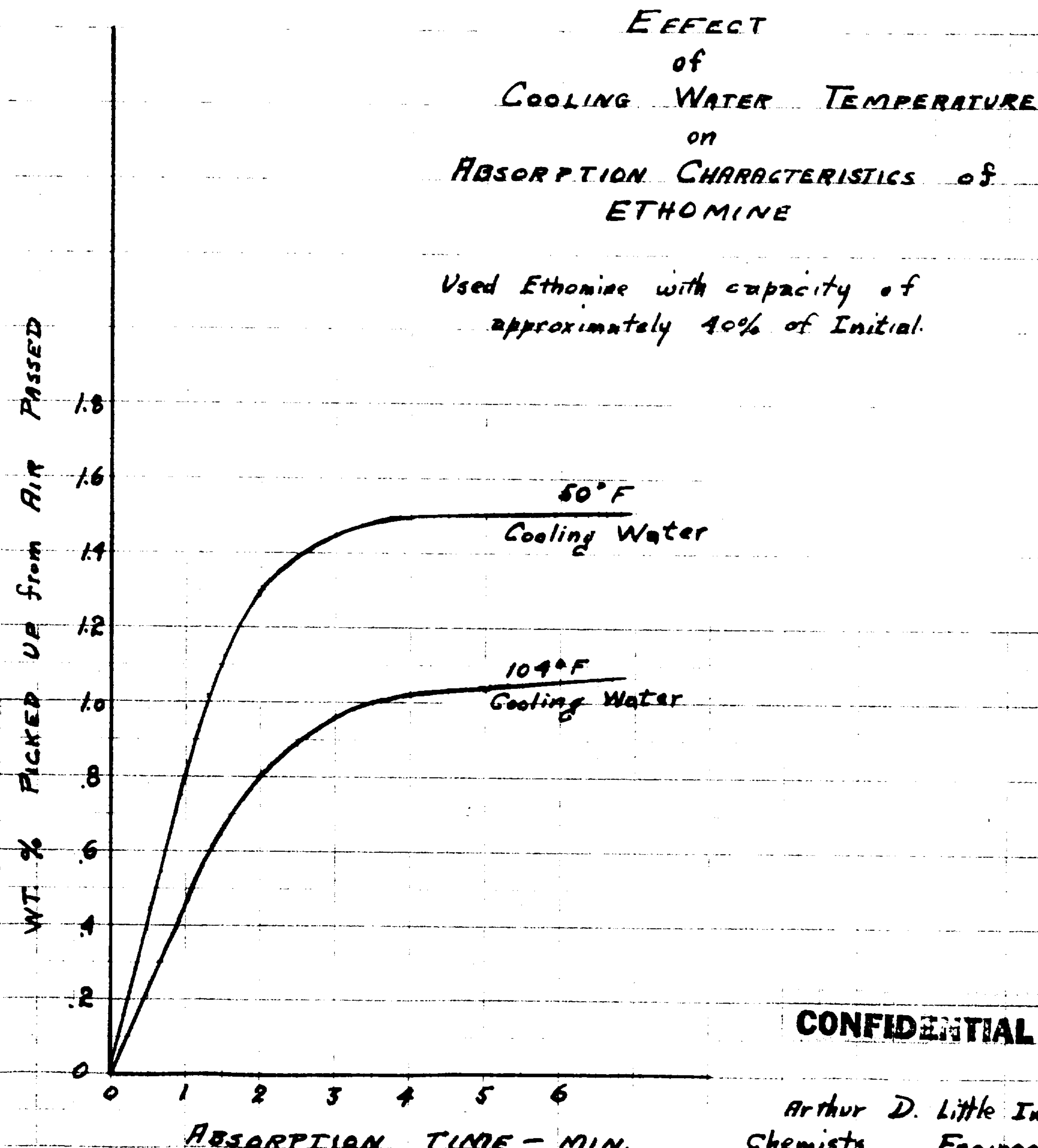
# PLOT IX

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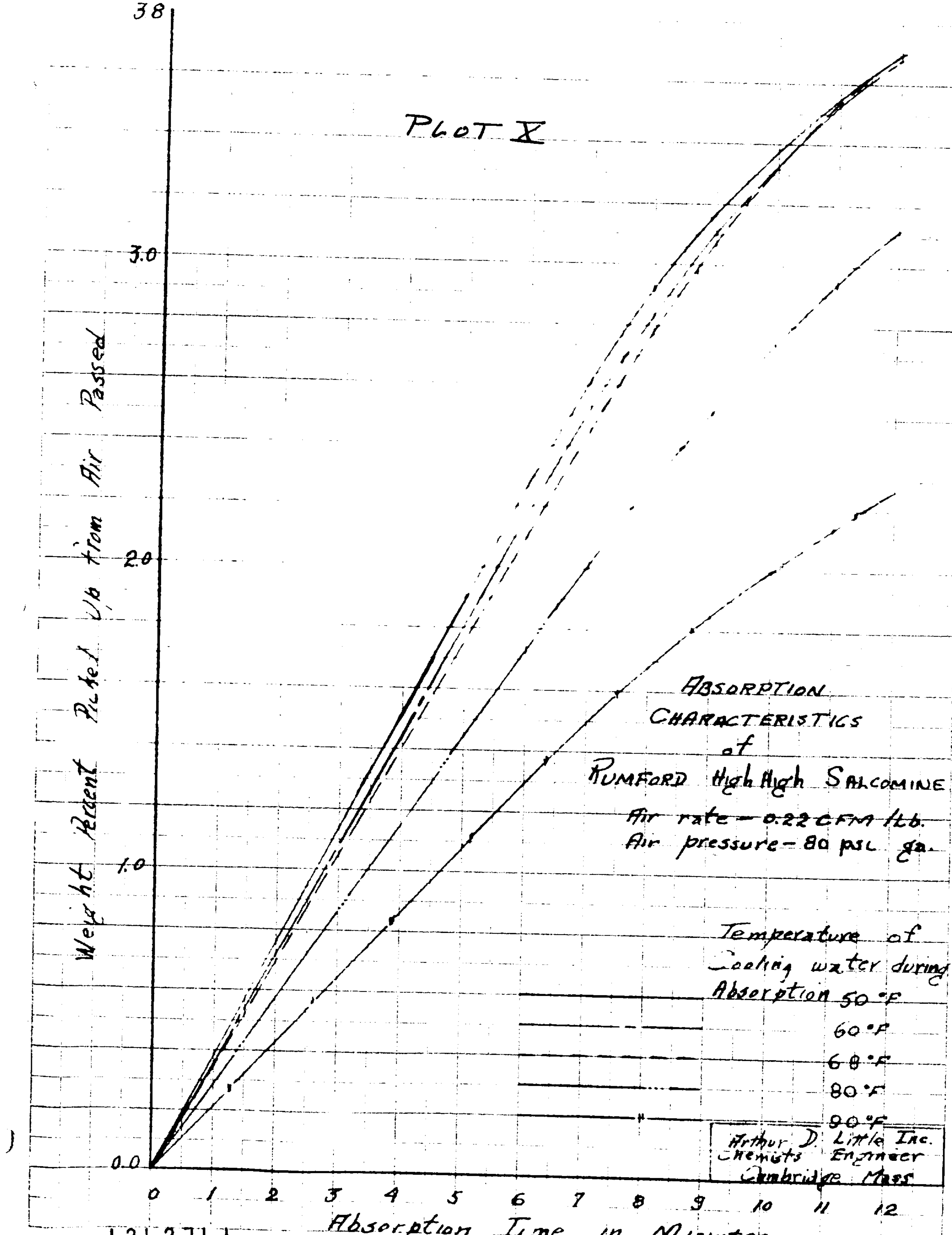


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The increase in rate with the lower temperature water is clearly seen in the absorption curves and longer life at higher hourly production is shown on the curves of loss in saturation capacity versus total $O_2$ produced.

These tests were made on rather highly degraded powder. It is hoped they may be repeated on fresh Ethomine at some time in the future.

Respectfully submitted,

Arthur D. Little, Inc.

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