numbers of centers of spread, and may materially reduce the percentage of wildfire in the crop when harvested.

14. Do not topdress fields on which tobacco is to be planted with stalks or refuse from badly infected crops.

15. Rotate tobacco with other crops if practicable.

PUBLICATIONS ON WILDFIRE CITED IN THIS BULLETIN.

Chapman, G. H. and P. J. Anderson. Tobacco Wildfire. Preliminary Report of Investigations. Mass. Agr. Exp. Sta. Bul. 203: 67-81. 1921.

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Fromme, F. D. and S. A. Wingard. Blackfire or Angular Leaf Spot of Tobacco. Va. Agr. Exp. Sta. Tech. Bul. 25: 1-43. 1922.

Wolf, F. A. and E. G. Moss. Diseases of Flue-cured Tobacco. N. C. Dept. of Agr. Bul. 40 (12): 24-34. 1919.

CONNECTICUT

AGRICULTURAL EXPERIMENT STATION

NEW HAVEN, CONN.

BULLETIN NO. 3 OF THE TOBACCO SUB-STATION

The Connecticut Agricultural Station,
E. H. JENKINS, Director, and
The Connecticut Valley Tobacco Improvement Association,
G. H. CHAPMAN, (Windsor), Research Director, Co-operating

Experiments in the Curing and Fermentation of Connecticut Shade Tobacco

FEBRUARY, 1923

Notice to Growers:

If you wish to receive future bulletins regarding tobacco, please send your correct address to the Station at New Haven or to the Association.

Experiments in the Curing and Fermentation of Connecticut Shade Tobacco, 1922.

G. H. CHAPMAN.

It is a well-established fact that the curing of tobacco is a life process, and that fermentation has to do with the changes taking place after the cells of the leaf are dead. It is readily understood, of course, that under certain conditions the two processes may take place simultaneously, particularly in the later stages of the curing.

As has been pointed out by Dr. W. W. Garner, of the Bureau of Plant Industry, curing involves principally the two somewhat similar physiological processes of respiration and translocation of mobile nutrients. The course of these processes, especially respiration, is greatly influenced by the prevailing temperature and humidity. These factors largely determine the character of the cured leaf.

Except in a rough way it is impossible to control temperature or humidity in ordinary shed curing of shade or stalk tobacco, and consequently in our climate, where rapid changes in temperature and humidity are prevalent, there usually is found, even in a crop of good growth, a wide variation in color and leaf quality in different seasons, and sometimes in the same season.

Many attempts have been made to perfect an artificial or controlled method of curing tobacco, but until automatic control apparatus was devised, little progress was recorded, which would tend to make the grower independent of weather.

The Carrier Engineering Co. of New York, and particularly Mr. A. C. Buensod of that company, have spent a number of years working on the application of control methods to the curing of tobacco, and to a certain degree they have been successful in devising satisfactory equipment for the control curing of cigar leaf tobacco. It was the writer's good fortune to have assisted for two seasons in the development of this process on a commercial scale in Porto Rico, and it was believed it would be possible to obtain satisfactory results on Connecticut tobacco. Some work along this

line had already been done by Mr. W. S. Pinney of Suffield, and Mr. Buensod. It was hoped that very interesting data could be secured without going to the expense of erecting a plant at the station this year, by using a cabinet of small dimensions holding a dozen or more sticks of tobacco, and on which cabinet the same control apparatus as employed in commercial plants was attached. A description of the cabinet used in these experiments is given below:

Description of Cabinet.

The cabinet is built of two galvanized iron casings with a two-inch layer of magnesia between to provide for sufficient insulation to protect the interior from being affected by any external changes

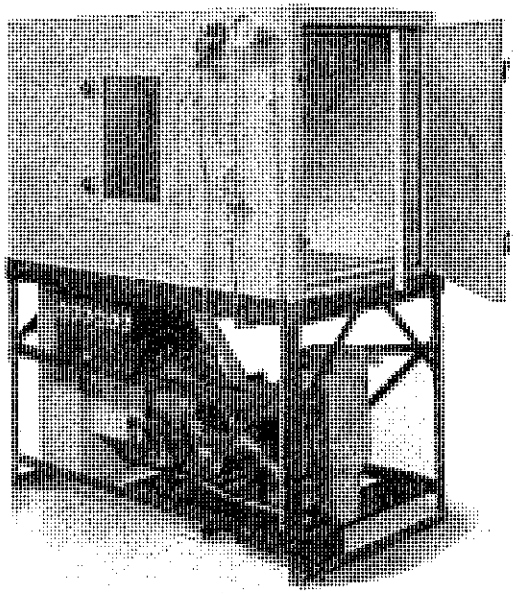

Figure 1. Carrier Ejector Processing Cabinet, showing arrangement of controls.

of temperature. Fig. (1) shows the general arrangement of the experimental cabinet with control apparatus in place. The air circulation within the cabinet is accomplished by the Carrier ejector system. Air from the fan is blown through a series of cone-shaped nozzles located across the end of the cabinet near the ceiling. The entire volume of air within the chamber is kept in constant motion following a circuit beginning with a rapid movement across the top of the chamber and completed by a slower movement in the opposite direction across the remainder of the chamber. Dampers control the relative amounts of fresh air or return air

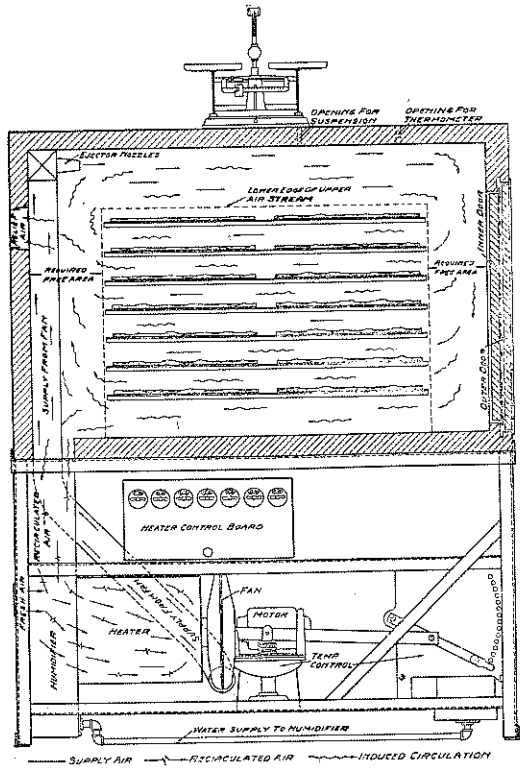

Figure 2. Cut showing air circulation in cabinet. Note particularly induced circulation.

used. Fig. (2) shows the movements of air currents in the chamber.

Humidification is brought about by atomizing spray nozzles operated by compressed air. Almost any humidity can be obtained at will. The humidity is controlled by a hygrostat which may be set at any desired point. The temperature is controlled by a thermostat which also may be set wherever desired. Once adjusted, uniform conditions of temperature and humidity may be maintained indefinitely, as the controls operate the heaters and sprays automatically.

Object of Experiments.

The several experiments which were carried on during the season are here outlined:

Experiment A. To determine the possible influence of plant maturity or time of picking on the color, quality, and yield of second priming Shade Cuban tobacco, all tobacco being cured with uniform temperature and humidity.

Experiment B. To compare the results obtained by artificial or control curing with the ordinary shed curing of second priming Shade Cuban tobacco, the tobacco for both tests being harvested at same time from same field.

Experiment C. To determine the effect of variations in temperature and humidity on the color, quality, and yield of third priming tobacco. This priming, as is well known, has a tendency to be rather dark in color, and either heavy or light as the case may be. The packers and manufacturers, however, declare that if light colors could be obtained in this priming that many of the leaves would make desirable wrappers, and this would enhance the value of the crop considerably.

Experiment D. To determine if the changes taking place in the process of ordinary bulk fermentation are comparable to those of artificial or control fermentation.

Experiment A. Influence of plant maturity or time of harvesting on color, quality, etc., of 2A (4th-7th leaves inclusive) priming Shade Cuban tobacco, curing conditions being uniform.

Mr. J. B. Stewart furnished two rows of tobacco for this experiment, and beginning at one end of the row, four leaves (4th-7th inc.) were picked at two-day intervals. Enough leaves were picked each time for four lath of tobacco, two for control curing and two for barn curing. The leaves were picked "running", no attempt being made to reject undesirable leaves or plants. This tobacco was set the 19th of June, and the first lot of 2A priming leaves was taken August 3d, forty-five days from time of setting. The last lot was taken August 28th, sixty-seven days from time of planting. The first lot would be classed by growers as too green, and the last lot as over-ripe. In this experiment the curing was carried on at a temperature of 95° F., and a relative humidity of 81-82%. Table (1) gives the data on the various pickings and the per cent of grades produced. For grading purposes, lots A, B, C, D (very immature to slightly immature) were grouped together as were E, F, G, H, I (slightly immature to mature) and J, K, L, M (mature to over-ripe).

TABLE I.

CURING EXPERIMENT A.

Control Cure.

Temperature 95° F.

Relative Humidity 81-82%

2A Picking (4th-7th inc.)

Tobacco Set June 19, 1922.

Tobacco from J. B. Stewart.

Lot.	Date of Picking.	Days in Field.	*Days in Cure.	Grouping of Lots for Grading.	†Grading % by Count.				†Grading % by Weight.				
					L	LV	LL	V	All Others.	L	LV	LL	V	All Others.
A-1	Aug. 3	45	8	A B C D	13.8	40.7	19.75	19.35	6.4	13.1	41.0	21.25	18.05	6.6
B-1	" 5	47	8		Top Grades 93.6					Top Grades 93.4				
C-1	" 7	49	8											
D-1	" 9	51												
			10											
E-1	" 11	53	8	E F G H I	25.0	52.0	11.8	8.95	2.3	16.65	60.0	11.65	8.35	3.35
F-1	" 13	55	8		Top Grades 97.75					Top Grades 96.65				
G-1	" 15	57	9											
H-1	" 17	59	9											
I-1	" 19	61	9											
			7											
J-1	" 21	63	7	J K L M	28.0	32.85	13.75	16.9	8.50	28.2	33.55	12.8	18.25	7.2
K-1	" 23	65	7		Top Grades 91.5					Top Grades 92.8				
L-1	" 25	67	7											
M-1	" 28	70	7											

* Leaf web all cured. Removed to shed to let stems cure out.
† Grading done after fermentation.

Control Curing. A study of the above table brings out some rather significant data on effect of maturity as related to the cure of tobacco, at least in so far as the season is concerned. While the actual number of days in the field would probably vary from season to season, the results on maturity effects would be the same. It will be observed that grading percentages are given not only by weight, which is the customary method of stating the yield of different grades, but also by count of leaves in the different grades.

It will be observed that in all three groups the percentage of the four top grades was higher than is obtained by the ordinary method of barn curing.

Lot A-D inclusive, green tobacco, yielded of L's and LV's 54.1 per cent, while lot E-I inclusive, slightly green, yielded 76.65 per cent, and the ripe to overripe tobacco in lot J-M inclusive, yielded 61.75 per cent of these grades. There can be no question but that lot E-I, picked from fifty-three to sixty-one days after setting in the field, yielded the largest amount of fancy tobacco, followed by lot J-M, consisting of ripe to overripe tobacco picked from sixty-three to seventy days after planting. The immature or very green tobacco, lot A-D, picked from forty-five to fifty-one days after setting, yielded the lowest percentage of L's and LV's. It is to be noted that in this grading the percentage of LV's is considerably larger than of the L's. The difference between these two grades was very little and, under ordinary sorting conditions, most of the LV's would be classed as L's. In fact, in lot E-I, after the sorting was completed one packer was unable to differentiate when the lots were mixed, between the L's and the LV's, and stated that they should all be put into one grade, L's.

It is also worthy of note that while in lot J-M, the percentage of L's by weight is greater than in either of the other lots, the drop in LV's is also much greater. It is also to be noted that on the very green tobacco the percentage of LL's is almost double what is found in either of the other lots. Another fact worthy of note is that in lot E-I, the percentage of the V grade is less than half that found in either lot, A-D or J-M.

The quality of the tobacco in lot E-I also was much better than in either of the other two lots.

The percentage of grades in all the lots, however, is very satisfactory, but this high percentage, of course, is due to the control of temperatures and humidities during the cure.

We are led to conclude from this experiment that Cuban Shade tobacco harvested slightly on the green side will yield a higher percentage of top grades than tobacco picked very green or ripe to overripe, and that with growing conditions approximating those of last season the second picking should be taken from fifty-one to sixty-one days after setting in the field.

Of course in a different season or under different growth conditions the yields might, and probably would, vary somewhat from those obtained this past season. It would seem questionable if we can ever get a definite time limit in which to pick tobacco in varying seasons, but possibly after further study it may be found that for a given set of growing conditions we may be able to closely approximate the period for taking the different pickings. Any data that would give us information on this point would be better than the haphazard way in which tobacco is picked at present. All observations to date indicate that much of the tobacco is harvested too late to give a maximum percentage of top grades.

With control methods of curing, however, it can be seen from the above that it is possible to extend the picking period over a considerable length of time and still produce a high yield of desirable tobacco. This can not be done in barn curing. This is brought out forcibly as a study of the results obtained in Experiment *B*, which is described as follows:

Experiment B. A comparison of artificial or control curing with ordinary barn curing of second priming Shade Cuban tobacco, the tobacco being taken from the same field and harvested on the same date.

The tobacco used in this experiment was from the same field as that used in Experiment *A*, and, as stated in the description of that experiment, double the number of leaves needed were harvested each time, one-half of each lot being used in Experiment *A*, and the others in Experiment *B*. The data as to setting and harvesting is the same as in Experiment *A*. The only difference between *A* and *B* is that *A* was cured under control conditions, and *B* was cured in the shed.

In Table (II) will be found the data together with the per cent of grades obtained from barn curing. As in Experiment *A*, lots A-D inclusive, very immature to slightly green, were grouped together, as were lots E-I inclusive, slightly green to mature, and lots J-M inclusive, consisting principally of overripe tobacco. As in the previous experiment the grading per cent is given by weight and count as well.

TABLE II.
CURING EXPERIMENT B.
Barn Cure.

Tobacco Set June 19, 1922.
Tobacco from J. B. Stewart.

Temperature Variable.

Relative Humidity Variable.
2A Picking (4th-7th inc.)

Lot.	Date of Picking.	Days in Field.	Days in Cure.	Grouping of Lots for Grading.	†Grading % by Count. L	LV	LL	V	All Others.	†Grading % by Weight. L	LV	LL	V	All Others.
A	Aug. 3	45	Until Cured	A B C D	0.0	13.05	10.55	23.6	57.8	0.0	10.3	11.95	24.05	53.7
B	" 5	47												
C	" 7	49												
D	" 9	51												
					Top Grades 47.2					Top Grades 46.3				
E	" 11	53		E F G H I	12.85	19.5	16.5	22.15	29.0	15.05	19.45	15.65	27.1	22.75
F	" 13	55												
G	" 15	57												
H	" 17	59												
I	" 19	61												
					Top Grades 71.0					Top Grades 77.25				
J	" 21	63		J K L M	3.0	13.4	19.0	31.3	33.2	2.15	18.85	21.45	34.0	28.55
K	" 23	65												
L	" 25	67												
M	" 28	70												
					Top Grades 66.7					Top Grades 76.45				

† Grading done after fermentation.

Before making a comparison between the barn curing and control curing, a discussion of the per cent of the various grades produced in the different lots of the barn-cured tobacco is given, as this shows even more clearly than Experiment *A* the influence of maturity on percentage of high grades obtained. Lots A-D inclusive yielded only 46.3 per cent of top grades, of which only 10.3 per cent were L's and LV's. Lots E-I inclusive yielded 77.25 per cent of the four top grades, of which 34.5 per cent were L's and LV's. Lots J-M inclusive yielded 76.4 per cent of the four top grades of which only 21 per cent were L's and LV's.

Here is clearly indicated again that under growth conditions existing this past season, second priming tobacco harvested fifty-one to sixty-one days after setting in the field yielded by far the best tobacco. That which was picked too green produced only a comparatively small per cent of high grades, while the tobacco picked in the middle period as compared with the later period yielded totals of the four top grades nearly alike. It is significant to note in the overripe tobacco a considerably larger per cent of LL's and V's, which, of course, are less valuable, than in the tobacco picked in the middle period.

It is worthy of note that although in our barn curing of the tobacco we obtained for leaves picked in the middle period 77.25 per cent of the four top grades, Mr. Stewart, harvesting the same picking on the same field on August 13th (early in this period), obtained a yield of 90 per cent top grades in barn curing, which is rather phenomenal for this past season. It may be said that the run of top grades this year in Shade Cuban tobacco for this particular picking does not appear to run over 75 per cent, and on many plantations is much lower than this.

It is obvious that the time of picking is an even more important factor in barn curing than it is in control curing. We should particularly guard against picking the tobacco too green, but on the other hand, if it is allowed to mature, as it often is, the percentage of L's and LV's is reduced. It is sometimes very difficult to judge when the tobacco is ready to be harvested, but it is one of the most important factors in the production of desirable leaf, and in case of doubt the picking should be on the green or immature side, rather than wait for full maturity of the tobacco.

A direct comparison of the results obtained in control cured vs. barn cured 2A priming of Shade Cuban tobacco is given in the following table in tabular form. Duplicate lots of tobacco as shown in Tables (I) and (II) are compared:

TABLE III.

COMPARISON OF BARN CURE WITH CONTROL CURE.

Duplicate Lots Cured.

Lot.		Grading % by Weight.				
		L	LV	LL	V	All Others
A-D (very immature)	Control Cure	13.1	41.0	21.25	18.05	6.6
	Barn Cure	0.0	10.3	11.95	24.05	53.7
E-I* (slightly immature)	Control Cure	16.65	60.0	11.65	8.35	3.35
	Barn Cure	15.05	19.45	15.65	27.1	22.75
J-M (mature-overripe)	Control Cure	28.2	33.55	12.8	18.25	7.2
	Barn Cure	2.15	18.85	21.45	34.0	28.55

* In Mr. Stewart's 2A priming from this field picked with lot *F*, barn cured, which has been stated as sorting 90 per cent. four top grades, the grading was as follows: L's and LV's 73 per cent., LL's 17.3 per cent., V's 0.0 per cent., all others 10 per cent. This is closely comparable with results here.

It is unnecessary to go into further discussion of the results obtained by the two methods of curing. The conclusion is obvious. One point, however, is worthy of repetition; with control curing, aside from production of a higher per cent of desirable grades as compared with barn curing, the time during which tobacco *can be picked* and still yield very large quantities of top grades is at least three times as long as when the tobacco is barn cured.

If this or a similar process of control curing can be economically installed for Connecticut Valley tobacco, many of the losses now met with will be avoided and profit assured.

Experiment C. To determine the effect of variations in temperature and humidity on the cure, particularly as regards color of third priming tobacco.

The production of more light tobacco in third priming Shade Cuban would raise the value of the crop considerably, and in this experiment an attempt to secure data as to the temperature and humidity conditions necessary to bring about this improvement in the color of the third priming was made.

Owing to the fact that only one curing cabinet was available, it was impossible to secure data on tobacco picked on any one date, subjected to variable temperatures and humidities. It was necessary to proceed as in our other experiments, picking the tobacco at intervals, and varying the temperature and humidity conditions at different times. This, of course, necessitated the later picked lots of tobacco being cured under different conditions than the earlier, but it was not believed this would operate against the value of the experiment, as it is almost axiomatic that the riper tobacco gets, the lighter will be the *general* color, although as it ripens there is a great tendency to spotting and double colors. The tobacco used in this experiment was a third priming from the plantations of Messrs. Ransom and A. A. Clark. In the table given below is shown the date of picking, the length of time in cure, and the results obtained.

TABLE IV.

CURING EXPERIMENT C.

Control Cure.

bacco from { J. Ransom. / A. A. Clark. — Third Priming (13th-16th leaves inc.

	Date of Picking.	Days in Cure.	Temperature of Cure	Relative Humidity	Character of Tobacco Colors.
-1	Aug. 23	13	95° F.	81%	Fair (Light brown—dark muddy
-1	" 27	11	" "	"	Fair (Light brown—Red)
-1	" 30	10	" "	"	Fair (Light brown—Red)
-1	Sept. 1	10	" "	81-83%	Fair (Light brown—Red)
-1	" 4	10	95-100° F.	83%	Poor (red—dark muddy)
-1	" 5	9	" "	"	Poor (red—dark muddy)
-1	" 7	11	100° F.	"	Fair (Light brown—dark muddy
-1	" 9	10	" "	"	Very poor (blue black)
-1	" 11	9	" "	"	Very poor (blue black)

The conditions carried on lots A-D inclusive were 95° Fahrenheit and 81 per cent relative humidity. The relative humidity was then raised to 83 per cent, and the temperature to 100° Fahrenheit, lots *E* and *F* being subjected to this rising temperature and humidity, while lots *G* to *I* inclusive were cured uniformly at a temperature of 100° Fahrenheit and 83 per cent relative humidity.

We had no data to indicate the probable optimum temperature and humidity to use as in the case of the second priming tobacco. Examination of the different lots after curing would indicate that the curing of this third picking was much too fast, and that possibly lower temperatures should have been used. It will be noted that lots A-D inclusive, which were more immature tobacco and cured at a temperature of 95° Fahrenheit and 81 per cent relative humidity, are reported as fair in color, while the lots E-I inclusive, cured at temperatures from 95-100° Fahrenheit and relative humidity of 83 per cent, are very dark in color, muddy, and less desirable than barn cured third picking from the same field. Lots A-D inclusive, however, compare very favorably with the average run of third picking this past season, but there is not sufficient increase in light-colored grades of tobacco, and the results obtained in these experiments are negative. It is believed that with lower temperatures, keeping the tobacco alive for a longer period, more favorable results would be obtained.

It would seem that if we can subject third priming Shade Cuban tobacco to proper temperatures and humidities in a correct relation in control curing, it ought to be possible to produce light-

colored tobacco, and more work along this line is planned. It is known that under favorable conditions in barn curing, we occasionally get very nice third priming tobacco.

We know that late fertilization and other factors influence the character and composition of tobacco to a great extent, particularly the body and color; but as the development of color in curing is so dependent on temperature and humidity, it would seem that unless the leaf composition of the upper leaves of Shade Cuban tobacco is such as to preclude the control of the various changes, favorable results ought to be obtained.

Experiment D. To compare the changes taking place in bulk fermentation and in "open" or control fermentation of tobacco.

Mr. Buensod has been very much interested in the possibility of the control method being applied to the fermentation of tobacco as well as to the curing, and has done considerable work in Porto Rico along this line. Some of the tobacco, both barn cured and control cured, was in part bulk fermented at the warehouses of the American Cigar Co., and duplicate samples were fermented by the open method (so-called) in the experimental cabinet.

In this method the hands are pinned as closely as possible on the lath and hung in the cabinet and there subjected to the desired temperature and humidity. Some of the lots were fermented in the cabinet for a longer period than others, the temperature carried ranging from 114-115°, and the relative humidity 81-85%. The time of treatment varied from 5½ to 17½ days.

The results obtained were not encouraging although the tobacco *looked* to be fermented sufficiently, and the colors were set satisfactorily. A comparison of bulk fermented with control fermented tobacco in the duplicate lots indicated that the same changes had not taken place in the control fermented tobacco as had taken place in bulk fermentation. The evening and setting of the colors by both methods was satisfactory, but the elasticity and water retaining capacity of the bulk fermented tobacco was far superior to that of the control fermented lots. The taste of the control fermented tobacco was bitter while that of the bulk fermented was sweet and wholesome. Color comparisons between bulk fermented and control fermented tobacco as determined by alcohol, cold and hot water, and benzol extractions, showed that while residual green coloring matter was present in comparatively large amounts in the control fermented tobacco, it had almost disappeared from the bulk fermented tobacco; also the amount of brown coloring matter was much less in the control fermented than in the bulk fermented. The control fermentation in the cabinet seemed to affect more the surface of the leaf, and so far as could be judged, did not extend to the body of the leaf to any great extent. An analysis of duplicate lots of leaves after fermentation also showed that the reduction of protein content was not more than half as much as in the control fermented as in the bulk fermented tobacco.

On the whole it may be stated that so far as can be judged from this experiment, the fermentation of tobacco by the open or control method is not satisfactory. It may be that a variation of conditions would produce better results.

This same result has been observed in Porto Rican tobacco fermented by the control method, but there it developed that after ageing in the bale for some months, no difference between the bulk fermented tobacco and the control fermented could be noted. This would indicate that in bulk fermentation the tobacco is practically *finished* during the fermentation, but that in control fermentation the process is incomplete, and a considerable amount of *natural* after-fermentation occurs in the bale. There is one significant difference between the two methods which may be responsible for some of the varying results; that is, in bulk fermentation the tobacco is tightly packed together, and the quantity of air around the leaves is very small, and oxidation or other chemical changes probably differ from those in the control fermentation where the constant circulation brings large amounts of air in contact with the leaves. Complete analytical data on the different duplicate lots of bulk fermented and control fermented tobacco cured under the same conditions at the same time is not yet available, but this will be presented in a later report.

In conclusion, it is desired to acknowledge the co-operation of the Carrier Engineering Corporation in conducting these experiments. They not only loaned the experimental cabinet but defrayed a third of the cost of the experiment. Mr. A. C. Buensod, of the Corporation, also spent several weeks in Windsor, supervising the details of operating the cabinet.