Some Further Studies and Improvements On A. O. C. S. Oven

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A GOOD many years ago the determination of moisture was not given very serious consideration. This work was assigned, as a rule, to the youngest and most inexperienced man of the laboratory staff. Temperature controls in the various types of drying equipment were crude and very little attention was paid to uniformity of temperature and drafts in the different parts of the oven.

More recently the importance of more accurate moisture determinations has been realized and the various factors controlling moisture determinations have been made the object of study by various scientific societies.

Consideration was not generally given to the fact that in many instances we are dealing with substances that contain matter other than water, volatile at or near the boiling point of water or which carry water of crystallization and lose a part of their water at or below the boiling point of water. Any method which is based on loss in weight during drying in an oven, therefore means that the volatile matter driven off may or may not be 100 per cent moisture. Recognition of this fact has been taken and in some instances instead of "moisture" the determination is classed as "moisture and volatile matter," and carried out under specified conditions. Since even a slight deviation from the specified conditions means a change in the results obtained and a loss or saving in dollars and cents, it is very necessary that conditions throughout our drying ovens be maintained very exactly and uniformly.

Our society for many years has maintained a Moisture committee and as a result of studies of this committee our present Official Jacketed Glycerin Oven was adopted in 1928. The temperature of this oven is maintained at 101° C. by boiling glycerin solution, the concentration of which is kept constant by means of a reflux condenser. The top, bottom and side walls of the oven are covered at all times with the glycerin solution, with the exception of the door, which is made of well insulated material with suitable ports for the regulation of the air supply. Fig A shows a photograph of the oven.

A study of the uniformity of the temperature in the various parts of the oven was recently made in the following manner:

Temperature measurements were made by means of iron-constantan thermo-couples and a Brown Potentiometer, Model No. 135. The thermo-couples were made from spool calibrated iron and constantan wire No. 28, B & S gauge. The thermo-couples were individually checked against the boiling point of water and any deviation compensated. Each wire was insulated by asbestos sleeving. Twenty-seven thermo-couples were arranged in three layers of nine couples each evenly distributed throughout the interior of the oven. The arrangement of the individual couples is shown in Figs. B and C. The couples were supported on a light wire frame work attached to the inside of the oven door. This was done so that access might be had to the oven at any time without changing the relative position of the various couples. The couple wires were installed through a brass tube fastened to the center of the door, and sealed in places with asbestos cement. The cold junctions of the thermo-couples were brought together in thermos bottles and maintained at 0°C by means of an ice water bath. The terminals were brought into low resistance multi-contact switches so wired that the potentiometer could be instantly switched from any one thermo-couple to any other one so as to facilitate quick and accurate checking of temperatures without appreciable time lag.

The results in table D indicate that the actual temperature throughout the oven is extremely uniform. The temperature ranges from a maximum of 101.3 to a minimum of 100.9, or a deviation of ±.2°C. The figures represent two separate tests and check very closely. It should be noted that the front part of the oven near the door may be subject to greater radiation losses than the other parts of the oven. The lower tem-

(*Continued on page* 194)

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(*Continued from page* 189)

peratures exist in the front of the oven; which is probably due to the cold air entering the ports at the lower part of the door. However, actual studies of this cooling effect in the determination of moisture in various materials has shown that it is not of a magnitude sufficient to influence the results materially. Since actual results under trying conditions are of even greater interest than determinations of temperature alone, several series of tests were run, the results of which are shown in Tables 1 to 7.

In each of these figures the position of the moisture test in the oven is shown by its position in the table, the top row for each shelf indicates the row in the back part of the oven, and the bottom row those tests located in the front of the oven, near the door. In Table I the oven was filled with samples of the whole cottonseeds in official moisture dishes.

In this table it will be noted that on all shelves the samples nearest the door show slightly lower moisture, but on the whole the results are very uniform. The fact that these samples represent whole cottonseed should also be kept in mind since it is extremely difficult to weigh up a large number of 5 gram samples of whole cottonseed, all of which are identical.

The results shown in Table 2 were obtained when the top shelf was loaded with fumed seed of low moisture content, in other words, second moistures. The middle shelf was filled with half low and half high moisture seed, and the bottom shelf entirely with high moisture seed.

Table 3 shows the results of tests when the top shelf was loaded with original seed, the middle shelf with half original seed and half partially dried seed and the bottom shelf with partially dried seed. The results of tables 2 and 3 indicate that samples of low moisture content are not dried as satisfactorily when placed above high moisture material as when placed below. The difference, however, is not great.

Table 4 shows the oven loaded to capacity on all shelves with samples of tankage which is much more uniform than cottonseed. The averages on the three shelves are within less than .2 per cent, showing the effect of the uniformity of the samples on the results obtained.

The results in Table 5 were obtained on the same sample as shown on the previous table. However, the oven was only filled to one-third capacity. The determinations were arranged as illustrated, with sufficient space between to allow free ventilation through the oven. The results indicate that a large amount of ventilation is unnecessary since these samples show slightly lower results than those obtained when the oven was filled to capacity and ventilation was somewhat interfered with by having the shelves entirely loaded.

In order to ascertain the effect of the personal element on the results, six samples of cottonseed were sent to 16 various laboratories scattered all over the United States. These results, as shown in Table 6, speak for themselves. The maximum deviation from the average on all six samples was .27 per cent. Another series covering 12 miscellaneous materials as shown in Table 7, were sent to the same 16 laboratories and again, as you will note, the maximum variation is only .28 per cent.

These results clearly demonstrate the possibility of obtaining uniform results when stated conditions are maintained in a drying oven. Uniform conditions are much easier to maintain in an oven of the type of the A. O. C. S. oven than in any oven with which we are familiar. This is due to the fact that all portions of the interior of the oven are at one temperature with the exception of the door. There are no heating coils within the oven, and it is impossible to have hot spots of any magnitude in an oven of this construction. No thermostat is necessary. A large number of thermostatically controlled ovens are on the market, each with its particular type of thermostat, many of which have been developed to a point of great efficiency, but the fact remains that a thermostat is not infallible. Most thermostatically controlled ovens have periods of erratic behavior, and are subject to lag periods after each make and break of the contact points. In addition, a thermostat only controls the temperature at one point in the oven and its use does not assure uniformity in all parts of an oven.

While it has many advantages the official A. O. C. S. oven is not without points which could be improved upon. The current consumption in electrically heated ovens produced in the last

four or five years has been somewhat excessive and as has been noted in the preceding tables, there is a tendency for the front part of the oven to be a fractional part of a degree lower than the rear. Both of these points have been given consideration.

The original jacketed glycerin ovens which were made in the shops of Swift & Company were insulated with asbestos and therefore the amount of current necessary was considerably less than in the ovens supplied the trade by apparatus manufacturers following its adoption by the A. O. C. S. However, very recently the Precision Scientific Company has made an insulation for this oven which may be slipped over the ovens now in use. All new ovens will be insulated. A test on the current consumption of one of these ovens so covered, indicated that it required 16 k.w. hours per 24 hours of continuous operation, as against 38.5 k.w. hours in the case of the uninsulated oven. In the insulated oven an hour and 45 minutes was required to bring a cold oven to 101° C. with all three electrical heaters in service, whereas with the uninsulated oven two hours and fifteen minutes was required. Two heating units were necessary to maintain the uninsulated oven at 101° C. after the boiling point was reached, whereas only one was required for the insulated oven. Figuring the cost of current at 3c per k.w. hour, the saving on current would easily pay for the oven within one or two years, depending on the number of hours of operation.

Studies are now in progress and experiments are being made with a view to pre-heating the air used for ventilation to correct the slightly lower figures which have been noted on the samples dried in close proximity to the ventilating shutter.

Complaints have been made by some of the larger laboratories that the standard size oven has too small a capacity. This feature is being considered and larger ovens are being designed. The manufacturers of this oven are confident that special ovens of any reasonable size can be constructed, using the A. O. C. S. oven basic design, at a comparatively small increased cost, and they would welcome suggestions as to size.

Since the purchase of cottonseed has been placed on an index basis and the accurate determination of the percentage of moisture has become increasingly important from a dollars and cents standpoint, we should all be interested in the development of equipment which will give exact and reproducible results. The A. O. C. S. oven may still fall short of perfect satisfaction, however, some of the points outstanding in favor of this type of drying oven have been listed below. They are:

1. Simplicity of construction.
2. No moving parts.
3. Absolute impossibility of oven hot spots.
4. Speed of temperature recovery due to large volume of boiling glycerin solution.
5. No sample loss due to high velocity of air currents.
6. No re-circulation of saturated air.
7. Uniformity of temperature throughout the oven.
8. Comparatively low first cost and low cost of operation.

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New Government Bulletin on Tung Oil Appears.—Just off the press at the Government Printing Office, a well illustrated bulletin on Tung Oil has been published by the Chemical Division of this Bureau. The treatment given the subject is very comprehensive, such information being incorporated as sources of supply, shipping centers, consumptive uses for Tung Oil, its physical properties, and its interchangeability with other drying oils, of which a brief account is also given. There is greater interest in Tung Oil at this time, perhaps because of the initial commercial production of the oil from tung tree groves in Florida recently. The bulletin discusses this phase of the industry and the extent to which the tung tree has been cultivated, and where, in the United States. The bulletin is Trade Promotion Series No. 133 and may be purchased by remitting the sum of ten cents, to the Superintendent of Documents, Government Printing Office, Washington, D. C., or it may be obtained from any district or cooperative office of this Bureau.