The Circulating Rendering Process

Describing a Revolutionary Development in the Modern Art of Fat Rendering from Edible and Inedible Materials

By OSCAR H. WURSTER
President, Wurster & Sanger, Inc.,
Chicago, Ill.

IT IS the purpose of this paper to describe the Circulating Rendering Process[2] invented by Mr. T. K. Lowry, General Superintendent of Darling & Company, Chicago, Illinois, and developed at the Chicago Plant of Darling & Company.

Definition of Rendering

IN A broad sense the term rendering is applied to the combined operations carried out in rendering plants by the rendering industry.[3] In its more limited and specific meaning rendering "is the term applied to the trying out of animal fats, whether edible or inedible; that is, to the separation, by means of heat, of fat from tissue and cellular structure. In the trade a further distinction is sometimes made, extraction at high temperatures being called 'rendering', and extraction at low temperatures, 'melting'."[4] Rendering is also described as the extraction of oil by boiling out with water and as consisting of the process which involves heating of the tissues containing the oils or fats so that the cell membranes burst and the liquid fat flows out.

I emphasize the definition and meaning of rendering because in conceiving and developing the new Circulating Rendering Process the questions which naturally came first were: (1) What does rendering consist of, basically? (2) How are the basic requirements fulfilled by the old methods? (3) How can these basic requirements be accomplished more efficiently and economically, more in line with our present ideas of the proper conduct of process operations and in the light of our present engineering knowledge and experience?

[1] Presented at the Fifth Fall Meeting of The American Oil Chemists' Society, Chicago, Ill., October 29, 1931.
[2] Patents applied for in the United States and foreign countries.
[3] Cf. L. B. Zapoleon, "Inedible Animal Fats In The United States" p. 175; Fats and Oils Studies of the Food Research Institute, No. 3, Stanford University, California, December, 1929.
[4] Ibid. p. 77.

Former Methods of Rendering

RENDERING in the past has been carried out by three general processes known as kettle, wet, and dry rendering. Kettle rendering is carried out by heating the material in an open kettle with direct heat or with steam heat in a jacketed kettle, and with hand or mechanical agitation. Usually some water is added to prevent local overheating or scorching at the start of the operation.

Wet rendering, also termed steam and pressure rendering, is carried out in a closed tank. The material is charged into the tank or digester and is then subjected to a steam pressure of about 40 pounds, with open steam. These digesters, in general, do not have mechanical agitation, but one modification which provides for subsequent drying in the same vessel is so equipped. By this process considerable water is introduced and its final disposition must be provided for in subsequent operations.

Dry rendering is carried out in a closed, horizontal or vertical dry-cooker or dry-melter, either at atmospheric pressure or under pressure or vacuum, or with a combination of these conditions. The heating steam in the jacket is usually at 40 to 50 pounds gauge pressure. The cooker is provided with a heavy mechanical agitator to keep the heating surface clean, to facilitate the heat transfer and to prevent local overheating and scorching of the material. A priming charge of fat may be added to the charge of material before the heat is turned on.

In all rendering processes the fatty matter is preferably cut up into small pieces before being charged to the rendering vessel. This facilitates uniformity in the heating and cooking of the material and the consequent breaking of the fat cells and, also, the exudation of the fat from the solid material.

Objections to the Old Rendering Processes

OPEN kettle rendering is, of course, slow owing to the relatively small heating surface and consequent slow rate of heat transfer. When carried out in a direct-fire-heated kettle the process is wasteful of fuel and the fat has a scorched taste, is dark colored and is of variable quality. Rendering in open, steam jacketed kettles, conserves fuel, permits better heat control, and produces a more uniform product. The operation is, however, a slow one, does not entirely prevent scorching, and introduces complications such as increased F.F.A. due to the time element. It does not adapt itself to economical large scale production.

Since open kettle rendering is slow and not suitable for materials low in fat content because the recovery of fat is incomplete, there was developed the wet rendering process in which the fatty material is disintegrated by the direct application of steam under pressure. Most lard, prime steam lard, is today produced by this process.

The objections to wet rendering are the temperature required, usually that of steam at 40 pounds pressure, the time required, which is usually 7 to 10 hours, the production of tank water and necessary recovery of the nitrogen values therefrom, and the consequent complications of the process involved in recovering the fat, tankage and nitrogen content of the tank water.

With the above enumerated objections to open kettle and wet pressure rendering, the open kettle process was developed into what is now known as the dry rendering process. The comminuted mass is heated with agitation and melted in its own fat and moisture. As carried out, the process is a necessary compromise between the greatest possible economy of operation and a satisfactory product. The heating surface is relatively small, therefore the heat transfer is slow. The maximum steam pressure permissible in the jacket is 40 to 50 pounds. Even this temperature affects the color of the fat and there is scorching of the products. There is also a formation of gluey or mucilaginous materials at the temperature and under the conditions of the dry rendering process. The process requires from 3 to 10 hours, depending on the material and the size of the melter. The power required for the heavy agitator which turns over the mass and rubs it against the shell is high and the upkeep of cookers is high due to wear and tear of the agitator and internal friction of the material on the shell of the cooker.

Origin of the Circulating Rendering Process

WITH the merits and disadvantages of the above three rendering processes in mind, Mr. Lowry concluded that what was needed was a process which combined (1) quick heating, to reduce the time element and its effect upon color and F.F.A., (2) low temperature of the materials, to prevent discoloration and scorching, to keep down the F.F.A. and permit the use of exhaust steam at low pressures, (3) large batches to meet modern manufacturing requirements, (4) economical operation as regards steam, power and labor.

The quick heating and low temperature specifications required a relatively large heating surface with a rapid heat transfer. This indicated a tube heating surface such as has been adopted for boilers, evaporators, stills, and other heating equipment. The rapid heat transfer would need to be accomplished by forced circulation.

Considering the nature of the materials which are rendered and their physical conditions, the possibility of circulating them through heating tubes by pumping raised many questions and problems. It had not been done and there was naturally the question of whether or not it could be carried out practically.

Using low temperatures would permit the use of exhaust steam and affect a great economy of operation. To use a low rendering temperature and exhaust steam for heating would require carrying out the process under vacuum. Just how the materials in process would act in a circulating rendering system carried out under vacuum remained to be determined. There was no experience or data available on the question.

In other words, the problems of pumping the mixed solid and liquid materials, passing these materials through heating tubes, possible frothing of the materials under vacuum as the moisture passed off, and necessary operating conditions could not be solved except by actually building and operating a plant. There was no data or experience available on the exact relation of the temperature and time factors of rendering under different conditions. Assuming that, from calculations, the proper heating surface was provided to give a certain heat transfer in a given time, there was no definite knowledge or data to assure that in this time and at the temperature of operation with a high vacuum the material would be rendered and in proper physical condition for subsequent handling. The characteristics of the materials to be handled and the circulating process involved precluded the possibility of successful experimental or pilot plant operation. However, the possibilities, were considered sufficient to warrant proceeding with a commercial size unit and the design and construction of a plant were started early in 1930.

Description of Process and Equipment

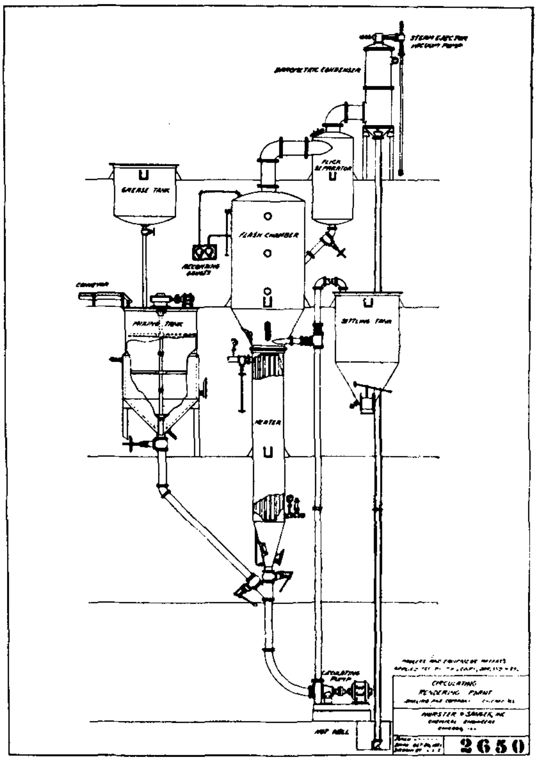
THE Circulating Rendering Plant consists of a tubular heating element with vertical tubes through which the material passes. The tubes are heated by exhaust steam at pressures below 5 pounds gauge. The material is drawn from the bottom of the tubes by a centrifugal pump of the non-clogging impeller type and is discharged at a point immediately above the top of the tubes to maintain circulation at this point and prevent clogging of the tubes. Above the heater is a large flash chamber in which the separation of the vapor from the liquid takes place. The vapor is drawn off from the flash chamber through a separator to a barometric condenser. A 2-stage steam-jet air ejector is connected to the barometric condenser to obtain the vacuum.

The material is ground and conveyed to a steam jacketed mixing and charging tank provided with an agitator in which it is heated before pumping into the heater and flash chamber. Whether or not a priming charge of fat is added depends on the kind of material, its physical condition and the amount of fat and moisture it contains.

After pumping the warmed material into the circulating system it is circulated through the heater until it is rendered and is then discharged into a settling tank. The fat is drawn off from the settling tank and the cracklings, or greaves, are run to the presses.

Operation of the First Unit

THE first unit built was designed for a total capacity of 20,000 lbs. material per charge, including priming fat. The average charge as the plant now is operated is slightly larger. The heater has slightly over 1,000 sq. ft. of heating surface with tubes of 4" outside diameter. Of the anticipated possible difficulties, it is of interest to note that frothing which became a problem with some materials has been overcome. The flash chamber is seven feet in diameter and has ample capacity for the release of the vapors from the liquid. The clogging of tubes has not been serious and has been overcome. The solids are in process of shrinking throughout the cooking operation, and the individual pieces entering the tubes naturally become smaller as they drop through.



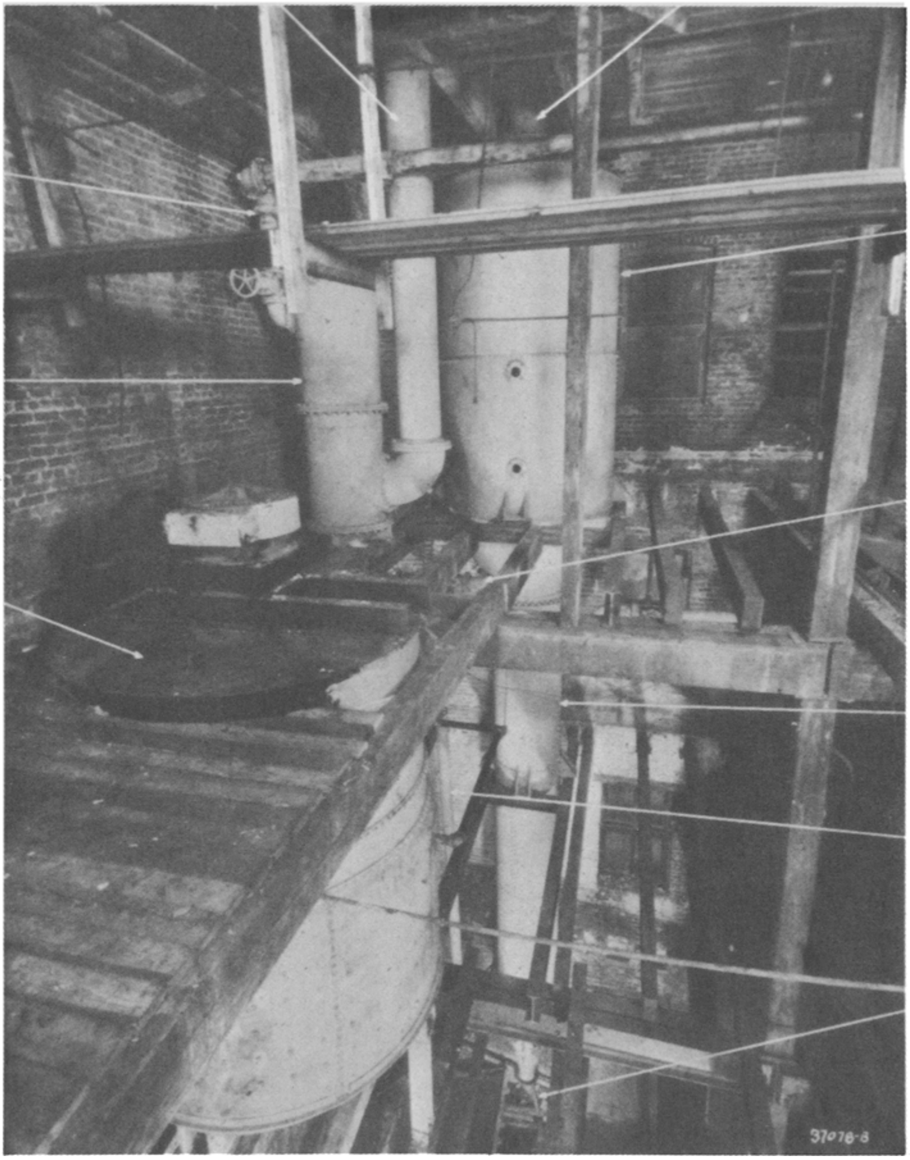
CIRCULATING RENDERING PLANT (Patents applied for)

Pumping problems developed at once and it was found necessary to reinstall the pump lines so as to overcome certain difficulties and several changes in pump design had to be made. The alterations in the pumps have not related to the proper functioning of the pumps as regards pumping. The non-clogging type impeller centrifugal pump has satisfactorily handled all the solids such as bones and meat and the foreign materials in garbage. The changes in pump design and construction were primarily to strengthen the pumps mechanically for this severe service and to keep them vacuum-tight under this service. The pumps in present use are functioning satisfactorily. Some minor changes in the original design of the equipment were also made as the development work progressed.

Results Obtained

ONE unit has now been in operation for over a year at the Chicago Plant of Darling & Company with satisfactory results. A second unit was recently installed at the Chicago Plant and has been in operation for several months. In this unit the heater is provided with tubes of 4½" outside diameter. Two units are now being installed at the Buffalo Plant of Darling & Company.

A charge of material is rendered in about 2 hours. As compared with dry rendering the



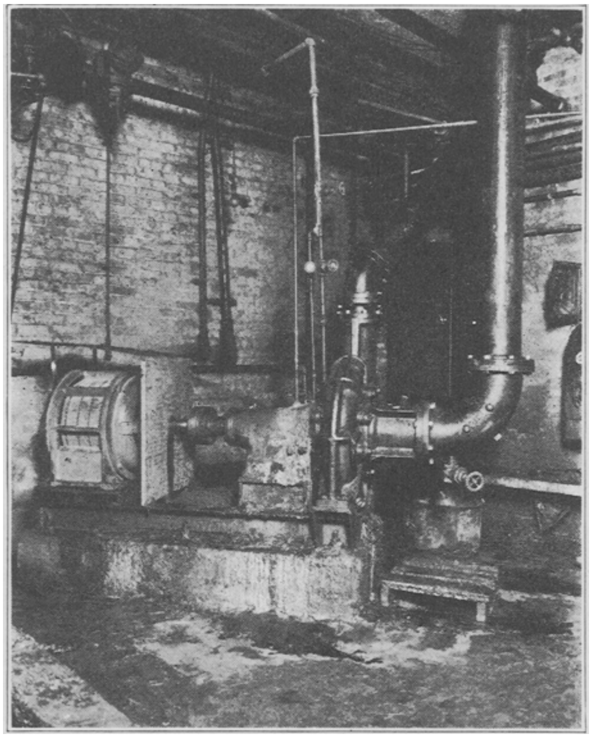
Circulating Rendering Plant

The Second Unit During Erection at Darling & Company, Chicago Plant

time varies inversely with the heating surface, with a further reduction due to better heat transfer resulting from rapid circulation. A 5′ x 16′ dry melter has a heating surface of approximately 250 sq. ft. However, the material resting on the lower portion of the shell is at no time in contact with the entire heating surface. The time of rendering a 16,000 lbs. charge is 8 to 9 hours. The Circulating Rendering Process with 1,000 sq. ft. heating surface renders the same size charge in about one fourth the time, or 2 hours. The use of exhaust steam at 5 lbs. pressure as against 40 to 50 lbs. in dry rendering lowers the heating temperature but this is offset by having the material under vacuum. In rendering, as in evaporation, the rate of heat transfer is approximately proportional to the difference in the temperature between the heating medium and the medium being heated. The forced circulation of the material over the heating surface is, of course, the chief factor in the rapid heat transfer and reduction in rendering time. The entire charge is circulated through the heating tubes approximately every three minutes.

The maximum temperature of the material is usually around 185 deg. F. and never above 200 deg. F. The vacuum runs up to a maximum of about 28″ at the finish. The color of the fat is better and the F.F.A. lower than with the old dry melters. With the lower temperature and shorter time of operation there is no formation of mucilaginous products.

Aside from the improved quality of the product there is a great saving in steam, labor and power. The heating is all done with exhaust steam which is available from the power generators. The amount of steam required varies with the moisture content of the material, but since much of the material rendered at the Darling Plant runs up to 75-80% moisture it will be readily appreciated that the total steam requirement is very high. The steam consumption is slightly under 1.2 lbs. exhaust steam at 4 lbs. pressure per pound of moisture driven off. The labor is reduced through improved handling which is facilitated by the larger batches in the Circulating Rendering System as against the old fat melters. Two Circulating Rendering Units are doing the work formerly done in ten dry melters. The power consumption is considerably less since the chief power requirement is that of the circulating pumps. On the two units installed at the Chicago Plant the circulating pumps have 30 H.P. motors. These render a minimum of 16,000 lbs. of material, each, in 2 hours. The old dry melters had 15 H.P. motors each, and it required 10 of these melters to do the same work, or 150 H.P. against the present 60 H.P. The motive power requirements may be further compared as follows: A horizontal dry melter 5′ diameter by 16′ long and driven by a 40 H.P. motor renders a charge of 16,000 lbs. of material in 8 to 9 hours. The Circulating Rendering Plant renders a charge of 16,000 lbs. material in 2 to 2½ hours and is operated by a 30 H.P. pump motor.



Circulating Pump on Circulating Rendering Plant

The Circulating Rendering Process is, as has been previously stated, operated under vacuum and all vapors are condensed in the barometric condenser. This precludes the discharge of any obnoxious vapors in the rendering of low grade inedible materials.

Since the only moving part in the Circulating Rendering Process plant is the circulating pump, there is expectation and assurance that the equipment will have a long life and that maintenance charges will be low.

The Future of the Process

THE Circulating Rendering Process is at present used commercially only on inedible materials including garbage, fat and bones.

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Fats & Oils As Food

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is large enough to produce pink discoloration provided the fat compound contains the colorless chromogen.

Discolorations ranging from greenish-blue to purple-blue have been observed in solid animal and vegetable fats. The microbiological process involved in producing the pigments is as follows: Certain yellow-producing cocci and some races of yellow-forming bacilli grow on solid fats at temperatures ranging from 39° F. to 99° F. The yellow pigment formed by these bacteria diffuses slowly into the fat. When the fat becomes rancid and peroxides appear, the pigment assumes a greenish color which in a few days deepens into blue. The original yellow pigment appears to be an oxidation-reduction indicator and can be oxidized with the usual reagents to a greenish-blue color and reduced back to the original yellowish pigment with reducing agents. Bacterial oxidases and peroxides will effect identical changes in the pigment.

Certain mineral oils such as machine oils can support the growth of oidia and other fungi provided moisture is present. These growths are often a nuisance in constant temperature oil baths. Bacteria may be found in machine oils but never grow well in this medium. Streptococci, staphylococci and B. pyocyaneus found contaminating machine cutting oils may give rise to skin infections if the oils are not treated with a disinfectant. Oils and fats exert a weak antimicrobic action and it is a common opinion amongst bacteriologists that certain oils are good preservatives. Hall and van Meter[11] observed that the preservation of peanut butter, for example, is due to the germicidal action of the peanut oil present. They did state, however, that they believed the organism died out because of the lack of available food.

Söhngen found a number of species of bacteria capable of oxidizing petroleum, paraffin oil and other hydrocarbons.[12] In garden soils, for instance, the number of paraffin oxidizing bacteria may reach 200,000 per gram of soil. Not a few species of bacteria show the power to elaborate lipase, likewise numerous species of molds, oidia, torulae and yeast hydrolyze and oxilize fats to a limited extent. Fortunately for the industry, only a few strict lipophilic microörganisms are present in nature.

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References

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[2] Oils, Fats and Fatty Foods, p. 394, E. R. Bolton—Philadelphia, 1928. For data on digestibility of high melting point fats see Langworthy and Holmes—U. S. Bulletin 310—Dept. of Agriculture.

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[12] Centrbl. fur Bakt. II, 37 595, 1913.

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Activated Carbon

(*From Page* 443)

year, they had been having a great deal of trouble. The condensate from the steam seals of the turbines had to be thrown overboard because of the oil it had adsorbed. This fresh water had to be bought in port, and it was thought advisable to make some use of it. Passing of the condensate thru columns of granular carbon removed the oil and made the water fit for boiler feed, without fear of "priming" or lost efficiency.

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Circulating Rendering

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From the standpoint of the physical condition of the material and the problems involved in handling, edible materials are more easily rendered by this process than the inedible. Several tests have been made on edible materials with satisfactory results.

With the present experience there is no other possible conclusion than that the Circulating Rendering Process is universally applicable for rendering on a large scale. Its use will result in improved products and considerable simplification and economy in operation.

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