Filtration and Bleaching

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FILTRATION is the most common method of separating solids from liquids and is especially useful where the amount of solid is relatively small as compared to the liquid. To complicate the rational study of the subject it is stated in one of the standard chemical engineering texts (1) that the apparatus used for filtration has been developed almost entirely from practical considerations and without relation to theory. Filters fall into a few general categories, each of which encompasses many variations. Only the general types will be covered here, with little attempt to cover the variations.

Strainers and Sand Filters. Two simple types of filters, strainers and packed-bed filters, should be mentioned in passing. Almost anyone who has installed a pump has protected it with a strainer which consists of a pipe-line fitting equipped with a perforated metal or woven wire basket designed to stop solid particles large enough to damage the pump. The packed-bed filters include small chambers packed with alumina, sand, cotton waste, charcoal, hair, Figerglas, etc., for purifying small streams of gases or liquids, as well as large sand filters, such as those used to filter water in municipal water systems. Sand filters are sometimes built as pressure filters for boiler feedwater by enclosing the sand bed within a pressure vessel.

Filter Presses. The filter press is probably the most widely-used apparatus for filtration. Many filters have been developed which are better for some applications, but in most cases the flexibility, simple construction, and relatively low cost of a filter press make it the logical choice. Filter presses have been built of many metals and alloys, of steel coated with rubber, plastics, and lead, and even entirely of wood. The filter medium used is usually a cotton duck or twill, but wire cloth, woven plastic fabrics, plastic coated cotton fabric, and paper have all been used successfully. Filter presses can be made in extremely large sizes, and it is not unusual to see them in edible oil refineries in sizes having 1,000 sq. ft. or more of surface. They are made in open delivery, closed delivery, washing types, heated, cooled, corner feed, side feed, and numerous other variations for special applications.

Filter presses are made in two general types, recessed-plate and plate-and-frame. Figures 1 and 2 illustrate the differences between these types of presses. The recessed-plate type generally has the feed channel through the center of the plate. The cloths, made up with center holes, are attached to the plates with grommets and are sealed at the outer edges by the flanges of the plates. This type of press is cheaper than a plate-and-frame type but has several disadvantages.

1. This type of filter is extremely hard on filter cloth because of strains imposed on the cloth when operating. Failures are usually at the center grommet or at the bend near the outer edge.
2. The cake is not uniformly thick and cannot be thoroughly blown, steamed, or washed.
3. Cake thickness is determined by limitations of cloth strength.
4. The cake usually has a soft core near the feed channel.

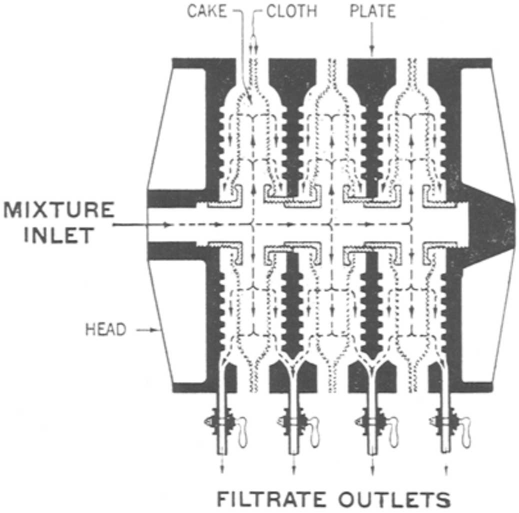

FIG. 1. Recessed-plate filter chamber assembly

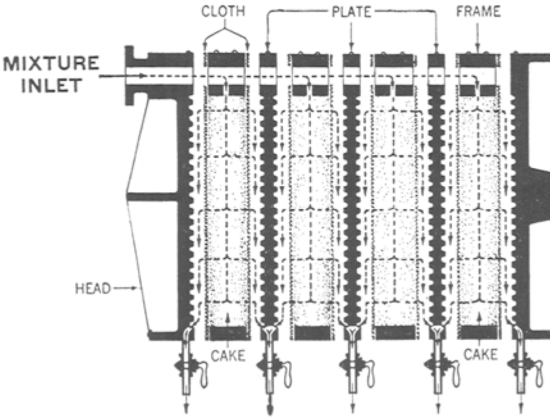

FIG. 2. Plate and frame filter chamber assembly

Some advantages are low initial cost, large feed openings that eliminate plugging problems on heavy slurries, and few joints to drip.

On the other hand, plate-and-frame presses are built with plates, which form the supporting base for the filter cloths, and frames, which are spacers between plates, forming the cake space. This type of construction has the following disadvantages: higher initial cost than recessed plate types, frames that contain relatively small feed ports which tend to clog with thick or lumpy feed mixtures, and twice as many joints as in recessed plate types, increasing the drip problem.

The major advantages are that strain on the cloth is practically eliminated and paper or wire cloth may be used, cakes are uniformly thick and can be more evenly blown or washed, cakes can be made any practical thickness by increasing the frame thickness, and cloths are held in place by hanging over frames and no fastening is needed.

Tank-Type Pressure Filters. A more modern type of filter is the leaf filter. These filters were originally developed in the metallurgical field where it is necessary to handle very thick slurries and to wash efficiently with small quantities of wash water. One type of leaf filter is illustrated in Figure 3. It is obvious that this type of construction gives a filter which is easier to clean and neater to operate than a filter press. A "heel leaf" in the bottom of the tank allows the remnants of liquor in the tank to be filtered before opening. These filters are considerably more expensive than filter presses, and the operating advantages often are not sufficient to overcome this objection.

These filters are usually fitted with wire cloth filter leaves which must be precoated with an asbestos fiber or diatomaceous earth filter aid. This is a disadvantage when the filter cake is of value since the precoat material becomes a contaminant to the solids.

Of similar construction, but somewhat different in application, are horizontal-plate filters such as the one illustrated in Figure 4. These filters are usually dressed with paper and can be quite effectively used for "polishing" operations where filtrate clarity is of prime importance and the solids content of the feed is low. These filters can be cleaned quickly by the expedient of maintaining a spare, dressed cartridge in readiness, simply exchanging it for the dirty cartridge during a brief shut-down. This type of filter also can be equipped with special provision for filtering the last portion of material through an unused plate at the bottom of the cartridge.

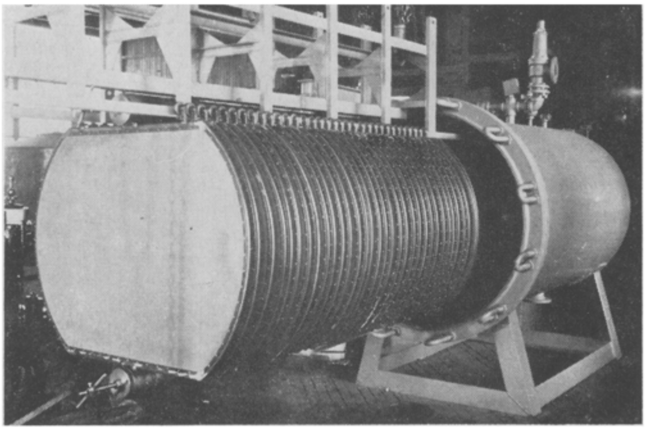

FIG. 3. Pressure leaf filter

Continuous Filters. In continuous processes, filtration through batch apparatus necessitates stand-by equipment to allow cleaning without interrupting flow. As this is expensive equipment to stand idle much of the time, continuous filters are highly desirable in continuous processes.

Probably the most familiar type of continuous filter is the rotary vacuum filter, such as is illustrated in Figure 5. This basic filter has many variations according to the particular application. The operating cycle of the filter is established by the "bridging" of a rotary valve. This separates the various drum segments into filtering, washing, drying, discharging, and cloth-washing sections as required.

These filters can be fitted with the filter medium beneath strings which are directed away from the filter drum proper at the discharge point, to expel cakes which are otherwise difficult to handle. In other cases, air is blown backwards through the cloth to dislodge the cake. One firm manufactures a filter which is precoated with a thick bed of filter aid. While operating, a doctor knife advances slowly into the precoat, discharging a thin film of the precoat at each revolution. This exposes a fresh filter medium at all times until the precoat bed has been exhausted, at which time it must be re-applied.

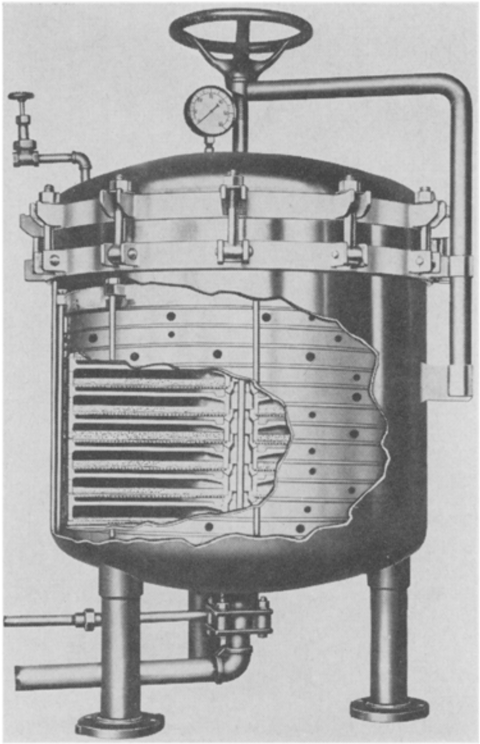

FIG. 4. Horizontal plate filter

Rotary vacuum filters can be enclosed in a vapor-tight housing to allow use in solvent-extraction or solvent-crystallization plants.

Another continuous filter is the horizontal vacuum filter illustrated in Figure 6. This type of filter is made up of horizontal segments which are revolved through various operations, such as feeding, cake washing, cake drying, discharge, and cloth cleaning. A vapor-tight model of this filter has been successfully used in the so-called "filtration-extraction" process developed by the Southern Regional Laboratory (5).

Centrifugal Filters. Not much used in the fats and oils industries, but interesting for some applications,

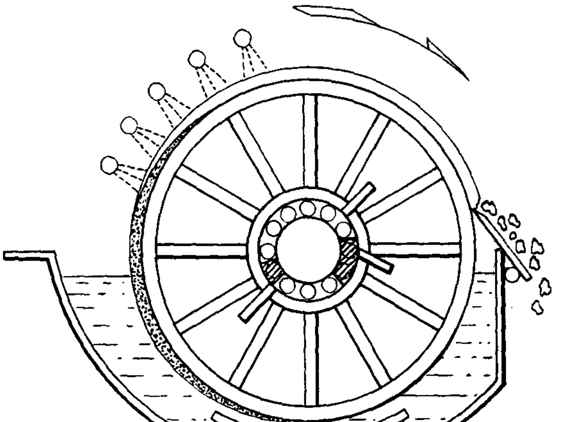

FIG. 5. Rotary vacuum filter

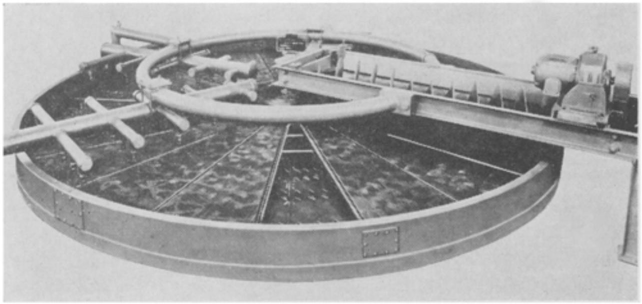

Fig. 6. Typical horizontal filter

are the centrifugal filters. One such machine is shown in Figure 7. It consists of a rotating perforated basket inside a housing which serves as the filtrate collector. The inside of the basket is lined with the filter medium. In operation, the machine is brought to operating speed; the feed slurry is introduced. Feeding is continued until a full filter cake has been built up on the filter cloth or screen. Then feed is discontinued, and the cake is spun until dry. It may be washed or steamed either before or after drying. When all possible filtrate has been removed from the cake, a plow is advanced into the cake while the basket rotates, discharging the cake either through the bottom of the basket or through a chute to the side.

These machines are made with both horizontal and vertical axis; the vertical axis machines are driven from either above or from below. These features are determined to a large extent by mechanical problems in building machines to rotate at high speeds with possibly unbalanced loads. They can be instrumented for completely automatic cycling so that observation is the only task of the operator. Speeds can be varied within the cycle to obtain maximum centrifugal force during drying and safe operation when plowing out cake. Basket centrifuges, like continuous filters, can be built with vapor-tight housings for hazardous locations.

Where elimination of cleaning labor is desirable, or where sufficient surge capacity is built into a continuous process to allow for the relatively short cake drying and discharge-time of a basket centrifuge, this equipment might find a definite application.

Filtration in the Fats and Oils Industry

Clarification. Even a fat which is used more or less in its crude form, if used for edible purposes, must be clarified to remove all foreign matter. For instance, lard and beef tallow are often used for edible purposes without any treatment to remove color, increase saturation, or remove odors and flavors. Yet it is a criterion of good quality that the product, when in the molten state, be clear and brilliant. Clarification and removal of traces of moisture are easily accomplished by adding a small quantity of diatomaceous earth to the fat as rendered, and by filtering. Crude vegetable oils are often filtered if appreciable quantities of solids, which would tend to interfere with further processing, are present.

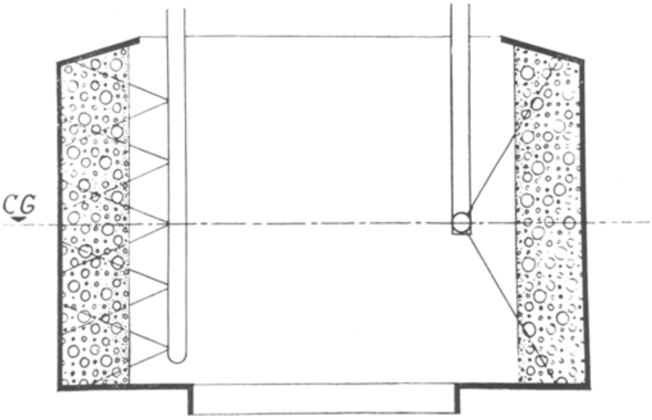

Fig. 7. Cross-section of centrifugal filter basket

Hydrogenation. A catalyst is necessary for hydrogenation of oils. Fixed catalysts have met with little acceptance in edible oil hydrogenation, and the common form of catalyst is finely divided nickel which must be removed after the hydrogenation reaction by filtration. Both filter presses and pressure filters are used for this service. Diatomaceous earth is necessary as a filter aid because of the extremely small particle size of the catalyst. Although some diatomaceous earth is part of most commercially available catalysts, addittional filter aid is frequently used. The cake from this filtration is often reusable as catalyst, and no attempt is made to get a dry cake since the oil present helps to protect the catalyst and is recycled into the next batch of oil to be hardened. Since the catalyst is quite fine and black, the "black-press" room is often unsightly in appearance even though the cake is treated with the greatest of care. Cleaning labor and catalyst handling can be reduced by using a pressure-leaf filter equipped with spray pipes for washing the cake out of the filter.

The oil from the catalyst filter is normally quite free of catalyst from an analytical standpoint (less than 20 p.p.m. nickel), but this small amount of nickel in colloidal suspension gives the oil an unsatisfactory appearance. A procedure known as "post-bleaching" is used to reduce the nickel content to an undetectable amount. The filtered oil is placed in a large agitated tank and a small quantity (about 0.1% to 0.2%) of bleaching earth is added, causing most of the nickel to be adsorbed on the surface of the earth. The earth, with the adsorbed nickel, is then filtered out, leaving the oil free from nickel and perfectly clear and brilliant. Since this filter cake is discarded, it is necessary, before opening, to blow or steam the cake to recover as much oil as possible.

Fractional Crystallization. Probably the most common application of fractional crystallization in edible oil processing is the "winterization" of cottonseed oil. Cottonseed oil contains small amounts of highly saturated triglycerides which cause the oil to become semi-solid at refrigerator storage temperatures. This is undesirable from the consumer's point of view and causes emulsion break-down if used in mayonnaise or salad dressing which is to be refrigerated. There has been considerable study made of continuous methods of winterizing cottonseed oil, both with and without solvents. Most of these processes have not been commercially feasible because of separation difficulties or high operating costs. It is reported that one such process is now in successful commercial operation, but there is no published information available at this time.

The stearine particles can vary from very small individual crystals to large agglomerates, depending upon the method of cooling. Regardless of the method of cooling, they are extremely soft and ill-defined.

Thus, if undue pressure is used to force the filtrate through the filter cake, it causes deformation of the crystals and bonding into an impervious mass which effectively blocks filtrate flow. Crystallization from solvents aids crystal formation and reduces the viscosity of the oil, but the cost of building such a plant is high due to vapor-tight construction and solvent recovery apparatus. Operating costs are high because of the expense of cooling and evaporating large volumes of solvent. This might be offset to some extent by higher winterized oil yields, but since the stearine is salable in any case, this factor is not of great importance.

In most cases the untreated oil is placed in a vessel equipped with brine coils and cooled over a period of 48 hrs. or more in order to form the most suitable crystals. At the end of the chilling period the oil is either forced by air pressure or pumped into one of several large filter presses located in a refrigerated room. Filtration is carried out at a constant low pressure; the flow rate is allowed to decrease as the resistance increases.

Filtration rates average about 2 lbs. per hour per square foot so it is seen that filtering one tank car per day of winterized oil requires 1,250 sq. ft. of filter surface, or two presses each having 40 plates, 36 in. square. If pressure leaf filters were used, this amount of surface would be quite costly. However these filters can be brine-jacketed to maintain filtration temperature, and the savings in refrigerated room space must be credited to the pressure-leaf filter. Continuous filters have seldom been considered for this operation, except in continuous chilling processes. Other oils, such as corn and soybean, are often "de-waxed" by a similar method. The quantity of wax is smaller than the cotton oil stearine, but the filtration characteristics are approximately the same.

Another fractional crystallization performed on edible products is the separation of oleo stock (beef tallow) into oleo oil and oleostearine. This is normally done by cooling in pans, ladling into canvas bags, and pressing in hydraulic or screw presses. Filtration would be less labor-consuming, but the filtration problem is much the same as in winterization, complicated further by the higher solids content. Since the cakes become compressed if too much pressure is used, and a thick cake offers high resistance to flow, a rotary vacuum filter is indicated. In fact, there are several processes (12) (16) developed specifically for fractional crystallization of fatty acids which rely upon continuous rotary vacuum filters. That these processes, with some modifications, are applicable to beef tallow separation is quite likely.

Final Polishing. Absolute clarity, which is of prime importance in those fats that are used in their crude state, is just as necessary in fats and oils that have undergone multiple stages of physical and chemical treatment. Deodorization is normally the final operation performed upon these fats prior to solidification and packaging and, if properly carried out, should have no effect upon the brilliance or clarity of an oil. However there always exists the possibility of solid matter in the deodorized oil. This may come from improperly cleaned storage tanks or lines, a dirty deodorizer, broken filter cloths, or from solid material introduced with the deodorizer blowing stream. Thus it is always good policy to provide, either in the stream leaving the deodorizer or between the deodorized oil storage tank and the oil's ultimate destination, a polishing filter. In order to assure utmost brilliance, this filter should be dressed with paper. The filter need have very little cake capacity since the oil will be virtually solids-free when it enters the filter. The horizontal-plate filter shown in Figure 4 is quite satisfactory for this purpose since it can be built with very shallow plates, giving a high ratio of surface to volume. The horizontal position of the cake allows intermittent operation without the cake falling off. The papers are supported over their entire area with no bends or creases and need no canvas backing. Filter presses dressed with paper backed by canvas, or leaf filters properly precoated, will polish equally well but do not have all the features enumerated.

Removal of Oil from Oilseeds. Oil is removed from oilseeds either by mechanical pressure, or by extraction with a solvent. In either case there may be particles of meal in the oil or the extraction miscella. In the case of expeller oil the bulk of the solids can be screened out, and this, plus a polishing operation in a filter press, gives a clear oil. In an extraction plant however the presence of fine meal particles in the miscella can be the cause of major headaches. These fines, if carried into the solvent removal equipment, can cause serious fouling of evaporators or strippers. Obviously the best way to prevent fines from being a problem is to prevent them from forming. A great deal of the effort in extraction-plant design in recent years has been directed toward this goal, particularly in plants designed for cottonseed extraction. If fines are present in the miscella however, there are several means of removing them. Some extraction plant designs utilize the bed of flakes as a filter medium with good success, others use settling devices or continuous centrifugals. All these are successful to some degree but leave varying quantities of solids in the miscella which must be removed by filtration, usually through a leaf-type filter.

Bleaching. Now that a variety of the applications of the unit operation of filtration have been discussed, there remains one phase of edible oil processing where filtration is an essential factor, namely, bleaching. There are changes in the color of a vegetable oil at nearly every step in processing. The most pronounced change is usually in the alkali-refining step. Also noticeable are reduction of color through chemical changes in the pigments during hydrogenation, and further reduction of color due to the high temperatures employed in deodorization. Since all these effects combined do not give an oil light enough in color to satisfy today's demands, there must be a treatment designed solely to remove pigmentation. There are two broad methods of doing this, chemical and physical. Chemical bleaching has been widely studied, but since most chemical methods of bleaching depend upon oxidation for their effect, the net result is an oil which has little or no ability left to resist oxidation. Very little fat, except that used for inedible purposes, is bleached by means of chemical agents. The most common method of bleaching edible fats is adsorption of the pigments by means of solids such as fuller's earth, acid-activated clays, or activated carbon.

The natural bleaching earths are composed mainly of hydrated aluminum silicate. Their activity varies, but no method of correlating activity with composition has been discovered. The activated earths are usually inactive clays which have been treated with either hydrochloric or sulfuric acid. Usually activated earths will retain much more oil than the natural earths, on a unit weight basis. However their much higher adsorbing power frequently more than compensates for this apparent shortcoming. The activated clays, especially those which are slightly acid, are almost indispensable for removing green color of chlorophyll from some soybean oils. The acid earths usually promote very slight increase in free fatty acid content of the oil during bleaching. This factor can be minimized by proper choice of bleaching conditions.

Activated carbon is seldom used alone in bleaching glyceride oils. Its adsorbing power is quite high, but its poor filterability and high oil retention are severe disadvantages. A small amount of carbon mixed with clay, usually in the proportions of 5% to 10% carbon in the mixture, provides a bleaching effect superior to that of clay alone, without excessive oil retention or decreased filtration rates. Carbon is highly effective in removing the "bloom" produced by mineral oil contamination and for removing certain pigments from coconut and palm kernel oil (2).

The choice of adsorbents for bleaching is usually a matter of economics: balancing oil loss, cost of adsorbents, and specifications for the bleached oil. Laboratory tests seldom furnish a reliable guide as to the amount of adsorbent necessary on a plant scale so final choice is usually a matter of judgment based on past experience.

Very good reviews of bleaching theory are given in the second edition of A. E. Bailey's "Industrial Oil and Fat Products" (2), and in A. R. Baldwin's lecture on decoloration at the Society's 1949 Short Course (4). These are recommended reading for anyone who wishes to enter into the why and wherefore of adsorbent bleaching. The question of whether adsorption is physical or chemical in nature is as yet unanswered, but the fact remains that it is a surface phenomenon. The Freundlich equation (6) states that the amount of pigment adsorbed per unit weight of adsorbent is an exponential function of the amount of residual pigment. This is written mathematically as:

$$X/m = Kc^n$$

or

$$\log \frac{X}{m} = K + n \log c,$$

where: X = amount of pigment adsorbed
m = amount of adsorbent used
c = amount of residual pigment
K and n = constants.

Bailey's discussion makes clear that this equation may be used with either Lovibond red units or optical density at a specific wavelength as units of amount of pigment. From the form of the Freundlich equation it is obvious that a plot of $\frac{X}{m}$ *versus* c on logarithmic coordinates should yield a straight line with a slope equal to n, and $\frac{X}{m} = K$ when $c = 1$. This plot, all points determined at the same temperature, is known as an adsorption isotherm and is quite useful in determining the relative bleaching powers of two adsorbents or the amount of a specific adsorbent required to reduce a given oil to a specified color level. The value of K indicates generally the over-all effectiveness of an adsorbent while n indicates the range of decoloration where an adsorbent has its greatest effect. Bailey gives a tabulation of values for K and n obtained by different observers, using various combinations of adsorbent and oil. These results give an indication of the effects of bleaching with various types of adsorbents under laboratory conditions. The most practical use of the adsorption isotherms is the prediction, from limited plant data, of the amount of adsorbent required to reach a specified final color, or from laboratory tests, which of several adsorbents will best do the specific job at hand.

Bleaching conditions have been the subject of a great deal of study with much of it being directed toward studying the effects of bleaching in the absence of air. King and Wharton (8) made a study of bleaching under atmospheric and vacuum conditions and discussed four factors which have a bearing upon the final color to be obtained in bleaching. These factors are adsorption of color, removal of color by pigment oxidation, increase in color by oxidation, and stabilization against adsorption by oxidation.

Since it is recognized that any oxidation of the oil itself is highly unfavorable from a quality standpoint, and two of the four factors listed, both due to oxidation, are unfavorable to bleaching efficiency, it seems logical that exclusion of oxygen from the system is of prime importance. King and Wharton definitely concluded that lower colors result from vacuum bleaching than from atmospheric bleaching and that oil bleached under vacuum or in an inert atmosphere is more stable than atmospherically bleached oil.

These and other workers (9) (13) (14) have also found that vacuum bleaching results in less formation of conjugated acids, causes greater soap removal, and allows the use of lower bleaching temperatures where activated earths are most effective. Normally bleaching temperatures range from 170°F. to 250°F., depending upon the oil and adsorbent, with the majority of bleaching done in the 200°F. to 230°F. range.

The adsorption process is an equilibrium process, and with good agitation the mixture should reach equilibrium within the short time of 10 min. Since the equilibrium is irreversible, the bleach is not affected by cooling prior to filtration.

Bleaching Practice. The oldest method of adsorbent bleaching is the open-kettle system, such as is illustrated in Figure 8. This system, despite the evidence that vacuum bleaching is more desirable, is probably used to bleach more oil today than any other. This is because kettles installed many years ago are performing quite satisfactorily so that quality factors and small savings in oil losses and adsorbent consumption can hardly be used to justify replacement.

In operation, the batch of oil, usually 30,000 to 60,000 lbs., is charged to the kettle and heated by steam coils while being agitated. When the temperature reached about 180°F., the adsorbent is dumped directly from bags into the kettle. When the maximum temperature is reached, the mixture is held at this point for about 20 min., then pumped through a filter to remove the earth. In this operation the oil is circulated through the filter and back to the kettle until the effluent stream is clear and some cake is present to give a "press-bleach" effect. This effect is a further decoloration obtained in the filter where

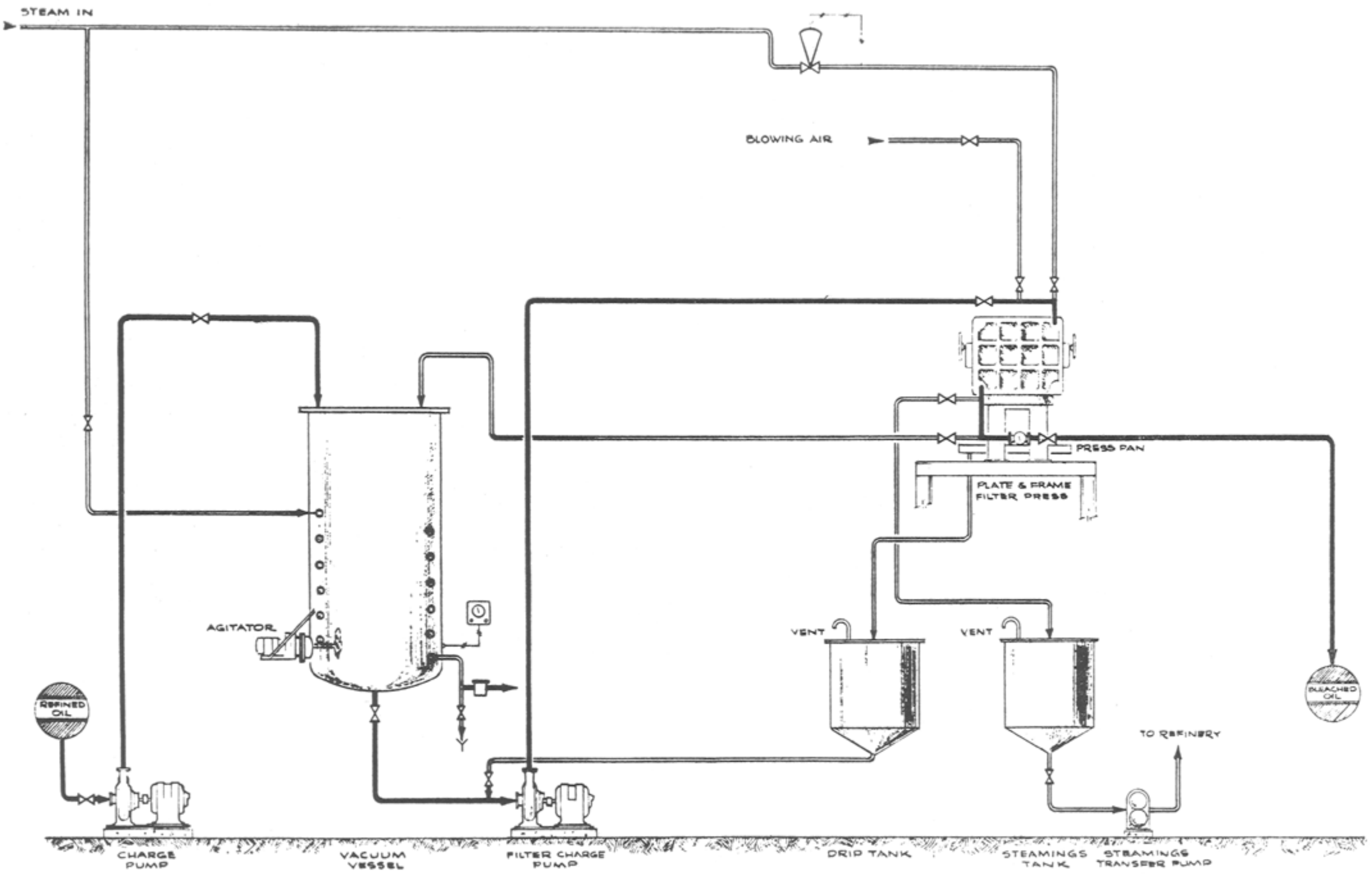

FIG. 8. Batch open kettle bleaching system

the ratio of adsorbent to oil is much higher than in the kettle. Plate-and-frame filter presses are used in most plants. Since the cake is usually blown with both air and steam after filling the press, a closed delivery press discharging into a vented tank is preferable to prevent steam and oily mist from being discharged into the room. In many plants open delivery presses are used, and numerous devices have been devised to lessen this nuisance.

The usual blowing procedure is to blow lightly with air until the bulk of the oil has been blown into the bleached oil receiver. Then the cake is steamed for about half an hour, with the steamings going to a separate receiver, and finally blown with air for 10 min. or so. After separating the water, this oil is returned for re-refining.

Many newer installations have been designed to take advantage of the beneficial effects of vacuum bleaching. Such a plant is illustrated in Figure 9. It is the same in most respects as the open-kettle system with the important addition of a steam-jet ejector system capable of maintaining a suction pressure of about 1.5 in. of mercury absolute. The kettle must now be built to withstand vacuum, and external slurrying of the adsorbent is essential unless a manhole is to be opened for charging prior to heating each batch. Charging dry earth directly to the evacuated kettle from a hopper is possible, but dust in vapor lines is a problem. Operating procedure is much the same as in the open-kettle system, but the range of bleaching temperatures is considerably wider. If it is found that a specific adsorbent is most effective at 170°F., the vacuum system assures that the oil and adsorbent will be well dehydrated at that temperature. If temperatures above 250°F. are indicated, vacuum operation assures that oxidation will not harm the oil in any way. The final color for a given adsorbent dosage and bleaching temperature will be lower than for an open system (or the same color can be reached with less adsorbent), and stability of the bleached oil will be greater.

Some of these newer systems have been designed to include pressure-leaf filters which contribute to the cleanliness of the operation and demonstrate a worthwhile savings in cleaning labor. Choosing one type of filter over the other is a matter of balancing a higher initial cost against a continuing higher operating cost.

There is little doubt when examining the Freundlich equation that earth which has been used to bleach an oil from a color of 5 Lovibond red units to 2 red units still has adsorbing power for an oil with a color of 8 red units. This suggests that bleaching in stages with countercurrent passage of earth and oil would result in more efficient use of adsorbent. This has been proved in laboratory and plant. It has also been shown that the countercurrent stepwise contacting procedure is practically useless in an open system, probably due to either oxidative stabilization of pigments or oxidative darkening of the oil (7). Adaptation of this principle to edible oil bleaching in batch systems has met with little success, presumably because of the difficulty of handling partially spent filter cakes and the deleterious effect of exposing the cake to air prior to reuse. The development of continuous bleaching systems has made this procedure more practical.

The petroleum industry has bleached petroleum stocks with continuous systems for years, using the

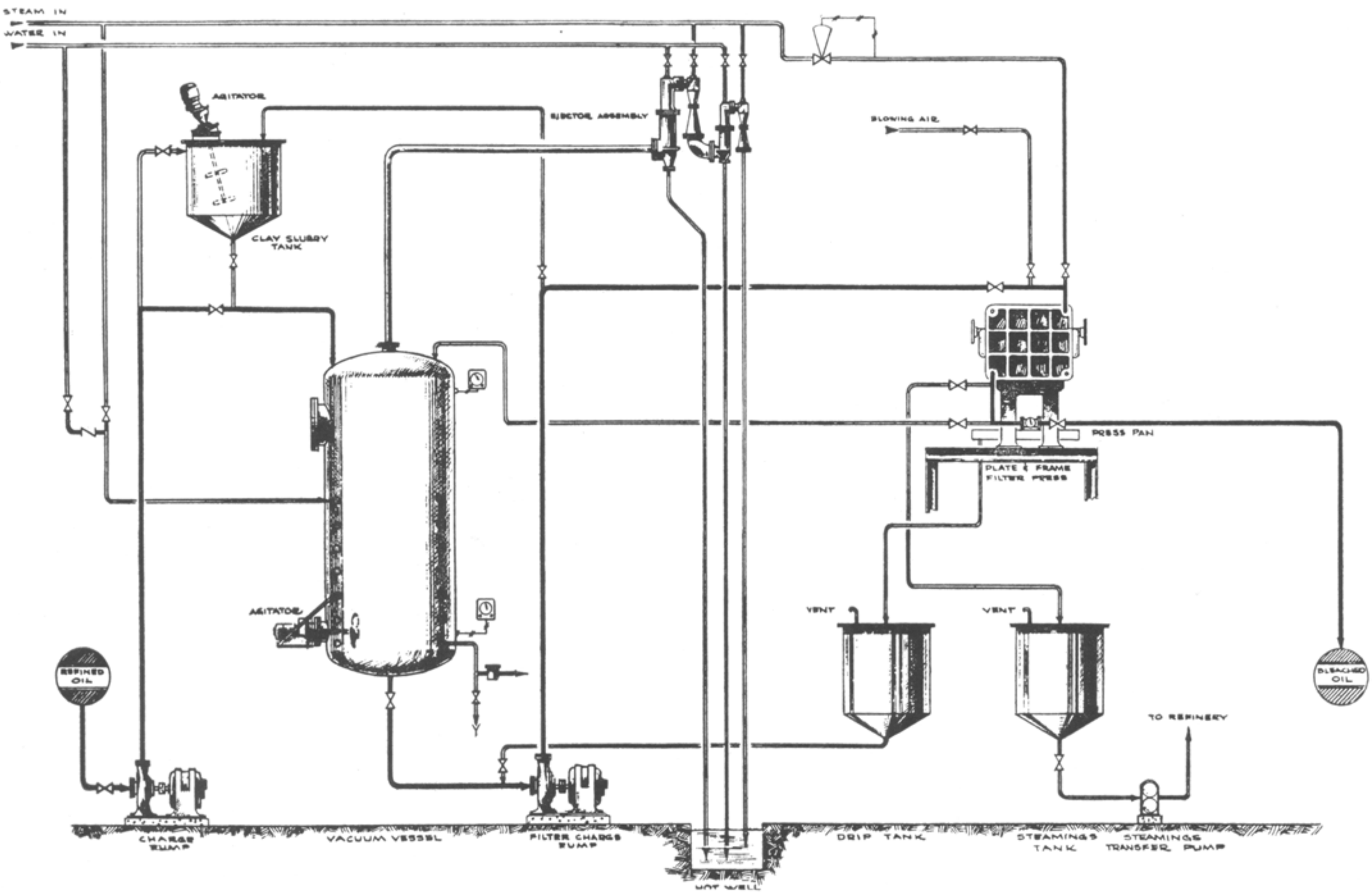

Fig. 9. Batch vacuum bleaching system

same adsorbents in slightly different form. The "percolation" system where the oil is pumped through a bed of adsorbent is an example. Probably the oldest continuous process in use in the edible oil field is that of King et al. (10). This process involves continuously mixing adsorbent and oil and spraying this slurry into the upper portion of a two-compartment vacuum vessel, where air and moisture are removed. The slurry is pumped through a heater which brings it up to bleaching temperature, then sprayed into the lower portion of the vessel for further dehydration. Here residence time of about 20 min. is provided, after which the oil is filtered and cooled. This process does not utilize the residual bleaching power of the spent earth but has several advantages, among which are deaeration and dehydration that are quite complete due to the spraying operations, and reduction of total time of oil-adsorbent contact, minimizing the tendency to increase fatty acid content.

A newer development bears a resemblance to the above process but features countercurrent use of the adsorbent (3) (11) (15). This process, as now operated commercially, is illustrated in Figure 10. The unbleached oil is sprayed into the lower section of a two-compartment vacuum vessel where it is deaerated and dehydrated. A small amount of live steam injected into the pool of oil in this section assists in removing air and moisture. The dry, deaerated oil is then sent through an economizer where it picks up heat from bleached oil, thence through a steam heater where it reaches bleaching temperature. Once heated, it passes through a filter bedded with adsorbent which has previously been used for the final bleaching stage. Here it utilizes the residual bleaching power of the adsorbent to reduce the color quite significantly. The once-bleached oil is then conducted to the upper chamber of the process vessel where it is introduced into a pool of oil. Fresh oil-adsorbent slurry is continuously being prepared by a volumetric feeder-agitated tank combination. Bleached oil is used for this slurry so that little or no adsorbing power will be used prior to meeting the main stream of oil. The slurry is sprayed into the upper section to remove any air and moisture present, then enters the main body of oil. A residence time of about 20 min., while being violently agitated by live steam, is built into this section of the process vessel. The oil-adsorbent mixture is then pumped to a second filter where the adsorbent is removed. The bleached oil from the filter then passes through the economizer and a cooler and is pumped to storage.

In this process three filters are shown. When a filter is filled with earth, it is placed in line as the prebleach press, and a clean one is placed in line as the final filter. The third is either being blown and cleaned or is dressed and ready for use. Both plate-and-frame, closed delivery presses, and pressure-leaf filters have been used in this process under both pilot plant and plant conditions. Although the pressure filter is more expensive, the short cleaning time required is advantageous in a continuous process such as this. Careful economic evaluation is required to arrive at a choice of filters for this process as for any other.

Some of the advantages claimed for the process are reduced operating cost because of the reduction in adsorbent dosage and oil loss, improved oil quality

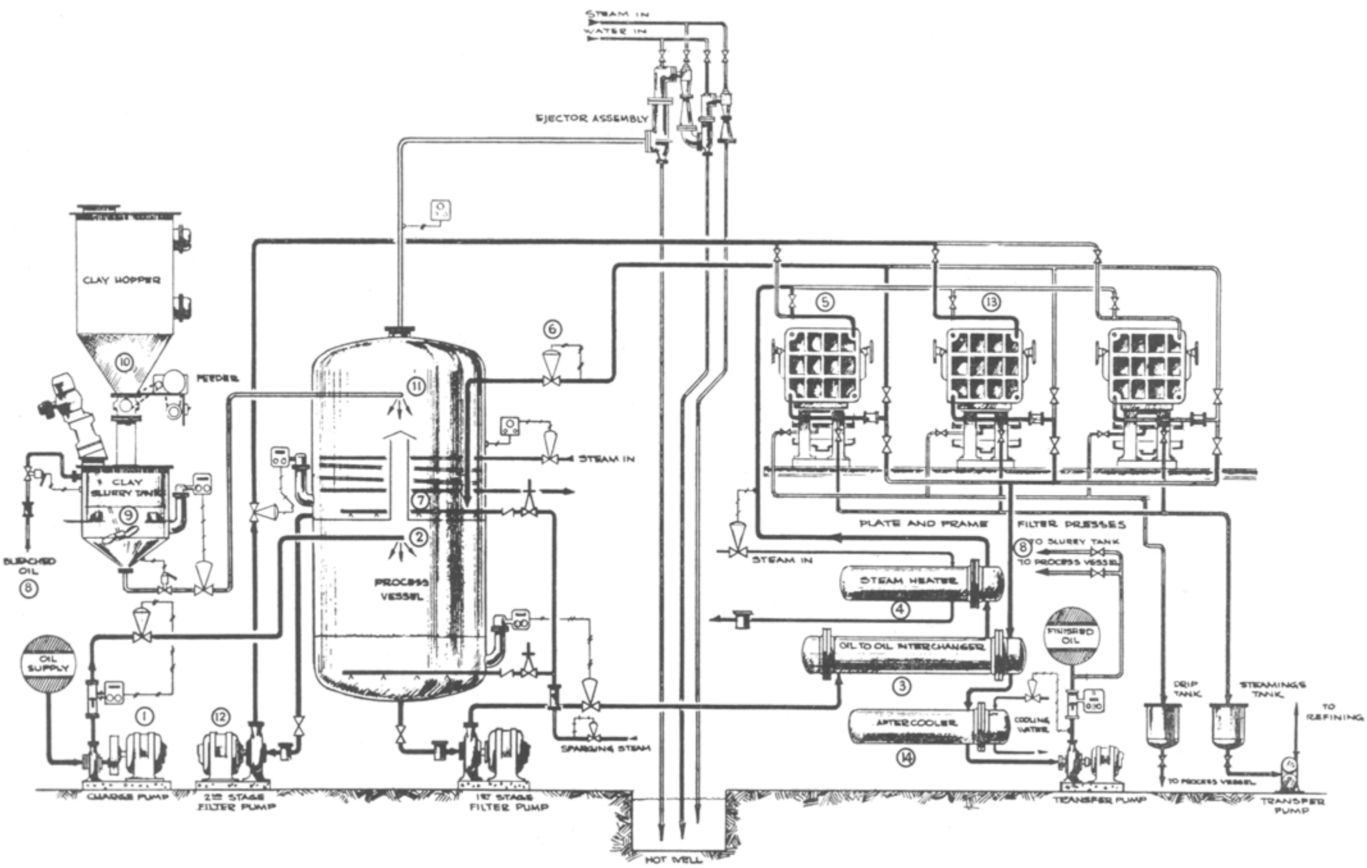

FIG. 10. Votator continuous counter current vacuum bleaching system

due to proper exclusion of oxygen, significant reduction in space requirements, especially in larger capacities, fully automatic operation from a centralized control station, cleanliness of plant, particular effectiveness in bleaching excessively dark oils, and approval of the B.A.I. for alternate use on animal and vegetable oils.

REFERENCES

1. Badger, W. L., and McCabe, W. L., "Elements of Chemical Engineering," 2nd ed., p. 467, New York, McGraw-Hill Book Company Inc., 1936.
2. Bailey, A. E., "Industrial Oil and Fat Products," 2nd ed., pp. 652–671, New York, Interscience Publishers Inc., 1951.
3. Bailey, A. E. (The Girdler Corp.), U. S. 2,618,644 (1952).
4. Baldwin, A. R., J. Am. Oil Chemists' Soc., *26*, 610–614 (1949).
5. D'Aquin, E. L., et al., Ind. Eng. Chem.,*45*, 247–254 (1953).
6. Freundlich, H., "Colloid and Capillary Chemistry," (translated from the 3rd German edition by Hatfield) London, Methuen, 1926.
7. Hassler, J. W., and Hagberg, R. A., Oil and Soap, *16*, 188–191 (1939).
8. King, R. R., and Wharton, F. W., J. Am. Oil Chemists' Soc., *26*, 201–207 (1949).
9. King, R. R., and Wharton, F. W., J. Am. Oil Chemists' Soc., *26*, 389–392 (1949).
10. King, R. R., et al. (Mrs. Tucker's Foods), U. S. 2,428,082 (1947).
11. McMichael, C. E., et al. (National Cylinder Gas Co.), U. S. 2,717,256 (1955).
12. Meyers, L. D., and Muckerheide, V. J. (Emery Industries Inc.), U. S. 2,293,676; 2,298,501 (1942).
13. Mitchell, J. H., and Kraybill, H. R., J. Am. Chem. Soc., *64*, 988–994 (1942).
14. Odeen, H., and Slosson, H. D., Oil and Soap, *12*, 211–215 (1955).
15. Singleton, W. A., and McMichael, C. E., J. Am. Oil Chemists' Soc., *32*, 1–6 (1955).
16. Spannuth, H. T. (Wilson and Company Inc.), U. S. 2,505,012 (1950).

Hydrogen Production

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THERE ARE MANY and varied ways of producing hydrogen for industrial use. However in the oil and fat industry there are only six sources of hydrogen that have been of any consequence and some of these to only a minor degree. These six sources are cylinder or compressed hydrogen, hydrogen produced as a by-product, hydrogen produced by the dissociation of ammonia, electrolytic hydrogen produced by the electrolysis of water, hydrogen produced by the steam-iron contact process, and hydrogen produced by catalytic steam hydrocarbon cracking. Practically all the fats and oils hydrogenated in the United States, Canada, and Mexico have been hydrogenated with hydrogen obtained from one of these six sources. The amount of hydrogen used from any one of these has been dictated by the size of the operation and economic considerations. Over the years the predominance of any one source has been almost entirely based on economic reasons alone. Emphasis on different methods of production has changed within the industry throughout the years.

Of the six methods of obtaining hydrogen in the oil and fat industry the so-called cylinder, bottled,