(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 761 807 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
12.03.1997 Bulletin 1997/11

(51) Int. Cl.[6]: **C11B 3/14**

(21) Application number: **96114524.0**

(22) Date of filing: **11.09.1996**

(84) Designated Contracting States:
DE ES FR IT

(30) Priority: **12.09.1995 US 527179**

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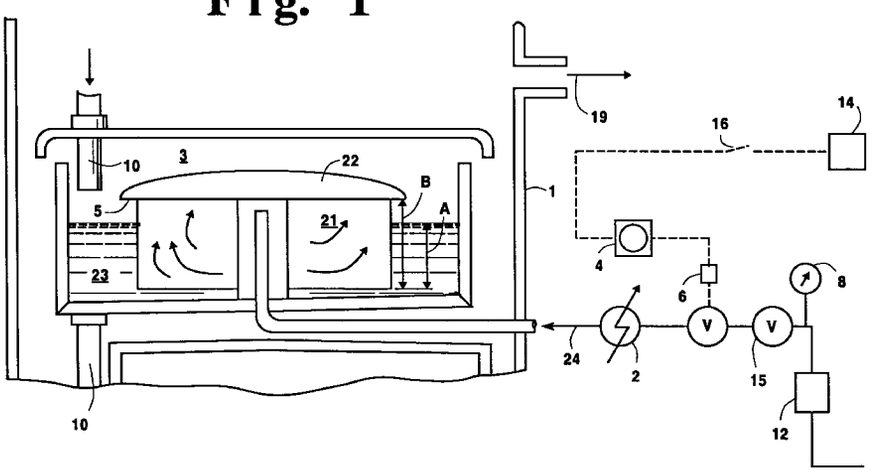
(54) Pulsation flow to optimize nitrogen consumption

(57) The present invention comprises a process for reducing the quantity of inert gas required to deodorize crude edible oil in a deodorizer, facilitated by intermittently supplying an inert gas, to produce edible quality oil.

In a preferred embodiment, the amount of inert stripping gas required for deodorization is minimized, while still accomplishing both the operation of gas lift umbrella trays in the stripping section of the deodorizer and effective removal of impurities from the edible oil.

Fig. 1



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Description

Field of the Invention

The invention relates to the use of inert gas as a stripping medium in deodorizing edible oil, and more particularly to reducing the amount of inert gas to less than the theoretical amount required for deodorizing edible oil, while maintaining operation of a deodorizer system.

Background of the Invention

Deodorization is usually the last major processing step in the refining of edible oils. It removes the undesirable ingredients occurring in natural fats and oils and also those imparted by prior unit operations. Commonly, edible oils or fats are subject to either chemical refining, involving degumming, neutralizing, dewaxing, washing and filtrating, or physical refining involving degumming, decoloring and filtering, prior to deodorization. The type of refining involved typically dictates the operating conditions of deodorization.

Deodorization involves stripping edible oils to remove, among other things, substances that impart disagreeable odor and taste. The substances removed usually include free fatty acids, various disagreeable odor and taste causing compounds, such as: aldehydes, ketones, alcohols, and hydrocarbons. Also removed are compounds formed by the heat decomposition of peroxides and pigments. These substances should be sufficiently removed to impart the desired property to the edible oil. For example, the fatty acids in the edible oils should be substantially reduced, to about 0.1 to about 0.2%, to obtain an edible oil having desired properties.

The deodorization process is normally carried out at a high temperature and under high vacuum in the presence of an inert stripping gas. Vapors are formed as a result of stripping the edible oils. These vapors which contain valuable by-products, such as fatty acids and other impurities, may be problematic for waste disposal. As a result, the vapors are usually condensed to produce condensates containing valuable by-products. Like deodorization, condensation is also carried out under high vacuum which can be generated by vacuum boosters and/or ejectors supplied with steam; steam utilized for condensation is referred to as motive steam. However, the vaporized impurities passing through the boosters and ejectors could contaminate the motive steam employed to supply high vacuum. Thus, the motive steam needs to be treated before it is disposed. Consumption of the motive steam in operating the deodorization process can therefore increase costs, unless its consumption can be reduced.

The use of steam as a stripping gas (process steam) is known in many deodorization systems. Process steam is suitable as a stripping gas because of its high specific volume, low cost and easily condensable and removable characteristics. The amount of process steam theoretically necessary to maximize stripping may be determined by the formula set forth in US Patent 5,241,092. The '092 patent discloses that to maximize stripping, commercial deodorization systems employ about 34 lb to 39.6 lb of process steam per ton of edible oil.

However, in spite of the minimum amount of process steam used in removing undesirable substances from edible oil, motive steam consumption is still high. The use of process steam may also lead to a reduction in deodorized edible oil product, due to the entrainment and undesirable side reactions, such as thermal decomposition and possibly hydrolysis reaction. An additional problem may arise in the use of process steam from the formation of a condensate containing a low percentage of fatty acid resulting from cooling the vapor formed during steam deodorization. The condensate with low fatty acid content needs to be further treated.

The above mentioned problems associated with using process steam have lead to the use of nitrogen or other inert gases to replace process steam as a stripping gas. Theoretically, equal moles of nitrogen or other inert gas are needed to replace equal moles of steam, to remove the same amount of impurities as steam. Unfortunately, this theoretical amount of non-condensible nitrogen or other non-condensible inerts as stripping gases would increase motive steam consumption as a result of passing an excessive amount of non-condensible gas to vacuum boosters and ejectors. Furthermore, the amount of cooling water required could be considerably increased for condensing the vapor formed during deodorization due to the overloading of the cooling system by the non-condensible inert gas.

Despite the above stated problems, US Patent 5,241,092 teaches that nitrogen can be used successfully to replace steam as a stripping gas in edible oil deodorizers. Because nitrogen is inert, when used as a stripping gas, mass transfer limitations due to entrainment and undesirable side reactions are minimized. The more effective mass transfer allows for a lower volumetric nitrogen flow rate, to less than 20% of the theoretical amount of steam, while still achieving efficient deodorization of the edible oil. Thus allowing nitrogen and other non-condensable inerts to be used without the adverse results on cooling water and motive steam requirements.

Many commercial deodorizers utilize umbrella type trays, such as those made by Votator, in the stripping section of the deodorization tower, which may be as large as 10 feet wide and 5 feet high. The stripping gas fed to the stripping section must be able to lift the oil through a concentric or gas-lift section of the tray up to the umbrella-shaped top of the tray and may have about a one foot gap between the concentric section and the top of the tray. Ordinarily, for a particular design of a stripping section with umbrella type trays, there is a nominal or design requirement for gas flow to operate

the umbrella trays. Some umbrella trays have conservative designs or nominal flow requirements which can be reduced to 50% - 80% and still be sufficient to operate the tray. This reduced flow rate is the minimum amount of inert gas needed to lift the oil to the top of the tray, independent of the theoretical requirement of inert gas for removal of impurities from the edible oil.

Due to the large cross sectional area of the gas-lift section, the gas flow required to operate this tray, even when reduced, can still become the limiting factor for the amount of inert gas required. This can be the case in spite of the fact that the actual amount of inert gas necessary to strip away undesired substances is considerably less than theoretical (as discussed in the '092 patent).

Conventional deodorizers have a constant flow of stripping gas to the trays in the stripping section during a deodorization run. A gas supply is only turned off when the edible oil is fully deodorized. This results in a high flow rate of inert gas to the stripping section, especially when umbrella-type trays are used because of operation of the gas lift section of those trays. Thus, conventional deodorizers do not satisfy the simultaneous requirement of reducing the inert gas flow rate (particularly in the stripping section) and physically operating the large gas-lift umbrella-type trays. Costs are also escalated due to a corresponding increase in demand for motive steam and cooling water as a result of the higher inert gas flow rate. Also, considering the cost of nitrogen and other inert gases, when operating with these trays in the deodorization section of the tower, nitrogen or other inert gas flow rate may not be reduced sufficiently to make the process economically feasible.

Objects of the Invention

It is therefore an object of the invention to reduce the amount of inert stripping gas required to deodorize edible oil.

It is another object of the invention to operate gas lift umbrella trays in the deodorizer with less inert stripping gas than the amount required to deodorize edible oil when a continuous gas flow is employed.

It is a further object of this invention to reduce the required amount of motive steam and cooling water without compromising the quality of deodorized edible oil when a non-condensable inert stripping gas is employed.

Summary of the Invention

The above mentioned objects and others which will be apparent to those skilled in the art, are achieved by the present invention, which comprises a process for reducing the quantity of inert gas required to deodorize crude edible oil in a deodorizer, by supplying an inert gas intermittently to produce edible quality oil.

In a preferred embodiment, the amount of inert stripping gas required for deodorization is minimized, while still accomplishing both the operation of gas lift umbrella trays in the stripping section of the deodorizer and effective removal of impurities from the edible oil.

Brief Description of the Drawings

Other objects, features and advantages will occur from the following description of preferred embodiments and the accompanying drawings, in which:

Fig. 1 is a cross sectional view of an umbrella type tray locatable in the stripping section of a deodorizer; and

Fig. 2 is a schematic diagram of a deodorization system which illustrates another embodiment of the present invention.

Detailed Description of the Invention

This invention may be accomplished by supplying an intermittent flow of inert stripping gas to the deodorization/stripping section of a deodorizer. An intermittent supply reduces the amount of inert gas required to simultaneously accomplish removal of impurities from edible oil and operation of gas-lift umbrella-type trays. Because an intermittent flow decreases the amount of inert gas required, per ton of edible oil, there is also a reduction in the amount of motive steam and cooling water employed in deodorization systems which could be operated in a continuous, semi-continuous or batchwise manner.

A typical deodorization system has a tower with a number of vertically spaced trays, all or some of which may be supplied with stripping gas. Crude oil, which may be preheated, enters at or near the top of the tower and travels from one tray to another via downcomers. Inert stripping gas is introduced to the tower through conduits fed to the bottom portions of the trays in the deodorization section of the tower.

Fig. 1 shows an embodiment of the invention, in which crude oil may be preheated and delivered to a deodorization chamber 3 in the upper portion of a tower 1. Any crude oil material including those which have been subject to at least one of degumming, neutralizing, filtrating, dewaxing, decoloring, bleaching, winterizing, hydrogenating, filtering and

deaerating steps or those which have been refined and deodorized but degraded due to the passage of time and/or exposure to oxygen, nevertheless, may be utilized. The level of impurities in the crude oil employed, however, may dictate the operating conditions of the deodorization tower.

Once crude oil is fed to the deodorization chamber, it flows downwardly over a plurality of vertically spaced trays (not shown in Fig.1) in the deodorization tower 1, via a downcomer 10. All or some of the trays may be equipped with stripping gas introduction means and indirect heating means. As crude oil material travels from one tray to another via downcomers 10, an inert stripping gas, which may be preheated by a heater 2, is introduced to the tower 1 through conduit 24.

Before an inert gas is introduced to the tower 1, it can be monitored by a flow meter 12 and a pressure gauge 8. The amount of inert gas entering the tower is controlled in one construction of the invention, by a needle valve 15, and should be at least a minimum amount necessary to produce a deodorized edible oil product having desired characteristics. The minimum amount of the non-condensable gas may vary depending on the types of edible oil and/or fats involved as shown in Table A of US Patent No. 5,241,092, the entire disclosure of which is incorporated herein by reference.

When an umbrella-type tray 5 is used in a deodorization section, the tray operates by having oil at a level in the collector 23, of about half the height of the umbrella tray 5. In one construction, the height, A, of the tray is 4 ft., and the level, B, of the oil in the collector is 2 ft. Oil within the outer concentric circle or gas-lift section 21 of the tray 5 is brought into contact with an inert gas which is fed via a pipe 24 into the inner circle section 20 and forced out under pressure through pores in the walls of the inner circle section 20, into the oil in the gas-lift section 21. The pores in the walls of the inner circle section 21, are arranged so that there are larger pores closely spaced at the bottom of the tray, which become smaller and farther spaced as the umbrella portion 22 of the tray is approached. Oil is lifted up through the gas-lift section 21, by the force of the inert gas, to the top of the inner surface of the umbrella portion 22 of the tray from which oil is returned to the static level in the collector 23, in the form of a spray.

Running a deodorizer with umbrella-type trays may require a greater amount of inert gas flow to operate than when other type trays are used. This requirement may become the limiting factor for the minimum amount of inert gas flow to deodorize the edible oil. It is no longer simply limited by the amount of inert gas required to remove impurities from the edible oil as this requirement may be considerably less than the inert gas required to physically operate the umbrella tray.

To operate a gas-lift umbrella-type tray means that a supply of inert gas to the tray is sufficient to circulate the oil by lifting the oil from the static level up to the umbrella top of the tray. The inert gas flow required to operate the umbrella-type tray may still be the limiting factor for the total amount of inert gas, even when 50%-80% of design flow of inert gas is utilized to operate the umbrella-type tray.

The invention minimizes the quantity of inert gas required to deodorize the edible oil, while using umbrella type trays by feeding the inert gas through pipe 24 in an intermittent fashion. A supply of inert gas is turned on for a period of time using a timer 4 and a solenoid valve 6. The timer 4 will send alternating on and off signals to the solenoid valve 6 each at a selected interval. The selected interval for which an inert gas is allowed to flow to a deodorization tray in one pulse ranges in one construction from about 0.5 to about 3600 seconds. In selecting this interval, two conditions must be satisfied: 1) when supply is on and an inert gas is flowing to a deodorization tray, the flow rate must be sufficient to operate the gas-lift umbrella-type tray, and, 2) a total amount of inert gas supplied to the deodorization tray for the residency period of oil in that tray is greater than or equal to the quantity of inert gas required to deodorize the oil.

The preferred mode is to alternate the on and off signals so that inert gas is supplied to an umbrella-type tray for a duration of about 30 to 60 seconds and supply is suspended for a duration of about 30 to 180 seconds. This sequence is repeated as long as the oil is in the deodorization tray, 30, 31, that is, for the residency period. Power is supplied to the timer 4 and the solenoid valve 6 from a power source 14 and may be controlled by a switch 16.

Intermittent flow may be supplied to only one umbrella-type tray in the deodorization section or to two or more trays. In any case, only the flow to the trays in the deodorization section of the deodorizer needs to be supplied in an intermittent manner. All other trays in the deodorizer may be fed with a continuous flow of inert gas.

During deodorization, vapors containing, inter alia, a non-condensable stripping gas, fatty acid and other odoriferous substances are formed. The vapors are withdrawn from the deodorization tower 1 through a conduit 19 which is in communication with a vacuum booster system or thermal compressor as shown in Figure 1 of US Patent No.5,241,092. In the vacuum booster system, motive steam may be supplied to a pair of vacuum boosters or to a series of pairs of vacuum boosters. These boosters may be used to provide a high vacuum in the deodorization tower which allows the vapors to be removed from the deodorization tower. Motive steam in the vacuum booster reaches a sufficiently high velocity to create a vacuum which entrains vapors from the deodorization column. The vapors and steam from the vacuum boosters may be introduced into a condenser where they are brought into direct contact with a jet of cooling water. Condensate resulting from cooling the vapors in the condenser is recovered and any vapors which are not condensed may be withdrawn from the condenser by means of a steam-jet ejector which is also supplied with motive steam. Motive steam in the steam-ejector reaches an even higher velocity than in the vacuum booster, thus, creating a stronger vacuum condition. The steam-jet ejector or a series of steam-jet ejectors may be used to provide a high vacuum pressure

condition in the condenser.

The amount of motive steam and cooling water required is dependent on, among other things, the amount of inert gas used in the deodorizer. It is thus preferable to minimize the amount of inert gas passing through valve 15 to reduce motive steam consumption and cooling water consumption in deodorization systems.

The system of Fig. 2, according to the present invention, utilizes intermittent inert gas flow to two umbrella type trays 30, 31 in the deodorization section 34,36 of the deodorizer. An intermittent timing sequence may be selected with the arrangement in this embodiment to further reduce the amount of inert gas supplied to the deodorizing chamber. Other chambers of the deodorizer with trays 32, 38 and 40 may be supplied with a normal steady flow of inert gas if desired. Inert gas is supplied to the system by pipe 54 which provides inert gas flow to all the chambers of the deodorizer, and which is measured and controlled by flow meters 52, 72, 82, 92, 102, pressure gauges 50, 70, 80, 90, 100, and needle valves 48, 68, 78, 88, 98. In this embodiment, the gauges and meters are used for manual operation, but one skilled in the art may well run this system in a completely automated mode. Trays 30 and 31 are supplied with inert gas which may be preheated in heaters 42 and 62. Inert gas flow, when supplied intermittently, is introduced via pipes 41 and 61 to trays 30 and 31, and flows to one or the other tray alternately. The two deodorizer trays 30 and 31 are operated in sequence so that the total nitrogen flow rate will remain constant. In this mode, inert gas flow to each tray is controlled separately. For example, the flow rate to tray 31, measured by flow meter 52, and timing controlled by timer 44 and solenoid valve 46 are measured independently from the flow to tray 30, measured by flow meter 72, and timing controlled by timer 64, and solenoid valve 66. The timers 44, 64 and the solenoid valves 46, 66 are supplied with power from a source 58 and are connected to that power source by a switch 56.

Table I shows comparative calculations for the deodorizer of Fig. 2, having gas-lift umbrella-type trays. The operating conditions for continuous operation of the deodorizer with gas lift umbrella-typed trays are as follows:

Edible oil flow rate:	200 TPD (tons per day)
Type of oil:	soybean oil, chemically
refined Deaerator temp.:	120-140 deg. C
Preheater temp.:	240-260 deg. C
Deodorizer tray 1 temp.:	240-260 deg. C
Deodorizer tray 2 temp.:	240-260 deg. C
Heat recovery tray temp:	180 deg. C
Cooling tray temp.:	105 deg. C

Table I

Deodorizer Sections	Nitrogen as a Substitute of Steam to Continuously Operate the Umbrella Gas Lift Tray	Minimum Nitrogen to Continuously Operate the Umbrella Gas Lift Tray	Minimum Nitrogen Flow with Pulsation Technique
Deaerator	7 ft^3/ton	7 ft^3/ton	7 ft^3/ton
Preheater	7 ft^3/ton	7 ft^3/ton	7 ft^3/ton
Deodor Tray 1	474 ft^3/ton	379 ft^3/ton	190 ft^3/ton
Deodor Tray 2	474 ft^3/ton	0 ft^3/ton	0 ft^3/ton
Heat Recovery	7 ft^3/ton	7 ft^3/ton	7 ft^3/ton
Cooling Tray	7 ft^3/ton	7 ft^3/ton	7 ft^3/ton
TOTAL	976 ft^3/ton (N_2)	407 ft^3/ton (N_2)	218 ft^3/ton (N_2)

Column 1 represents a deodorizer run continuously with inert gas, such as nitrogen as a direct substitute to the nominal quantities required for steam. In column 2 the deodorizer is run continuously with a minimum amount of inert gas, nitrogen, required to operate the gas-lift umbrella-type trays, (this quantity is 80% of the design flow rate for the umbrella-type deodorizer trays). A minimum amount of inert gas supplied intermittently is shown in column 3.

When nitrogen is substituted for steam, as in column 1, because of its superior qualities as a stripping gas, far less nitrogen is required than steam to deodorize the edible oil, except in the deodorization section with the umbrella type trays. In this section, the nitrogen equivalent flow rate is not reduced because of the gas flow rate required to physically operate the gas-lift section of these umbrella-type trays when the gas is supplied continuously. A continuous nitrogen

flow to the deodorization trays 1 and 2 must be kept at a design or nominal equivalent amount (i.e. 1 mole of nitrogen to replace 1 mole of steam). At this rate, the total volume of nitrogen will overload the vacuum system.

Column 2 shows the deodorization section run at a minimum flow rate to operate the gas-lift umbrella-type trays. Here the same amount of nitrogen is required in the other trays, but the total flow to the deodorization tray is considerably reduced as compared to column 1. Gas supply to the gas-lift umbrella-type tray is turned down, in column 2, to 80% of the design or nominal flow rate, shown in column 1, required to operate these trays. At this rate, the non-condensable inert gas can be accommodated by the vacuum system. In addition, deodorizer tray 2 can potentially be shut off completely as shown in column 2, since nitrogen is a substantially more effective stripping gas than steam.

Any intermittent mode may be selected for the intervals of on time and off time, as long as the instantaneous flow, is sufficient to lift the oil up through the gas-lift section of the umbrella-type tray and the total amount of inert gas supplied is sufficient to deodorize the oil.

In Table I, the selected timed interval is on for 30 seconds followed by off for 30 seconds. During each 30 second interval that the inert gas flow in on, the flow rate is 379 ft^3/ton as shown in column 2. This is the amount required to operate the tray, calculated as 80% of the design flow rate for this example. The total flow of nitrogen over the residence period of the oil in the deodorization tray is 190 ft^3/ton as shown in column 3. When this total flow in the deodorization tray is added to the flow in the other trays in the deodorizer the total flow rate of nitrogen supplied is 218 ft^3/ton. This is well within the range of 22 ft^3/ton to 230 ft^3/ton inert gas required for deodorization as disclosed in the '092 patent.

The preferred mode, with two deodorization trays in operation, is shown in Table II.

Table II

Deodorizer Sections	Nitrogen as a Substitute of Steam to Continuously Operate the Umbrella Gas Lift Tray	Minimum Nitrogen to Continuously Operate the Umbrella Gas Lift Tray	Minimum Nitrogen Flow with Pulsation Technique
Deaerator	7 ft^3/ton	7 ft^3/ton	7 ft^3/ton
Preheater	7 ft^3/ton	7 ft^3/ton	7 ft^3/ton
Deodor Tray 1	474 ft^3/ton	379 ft^3/ton	95 ft^3/ton
Deodor Tray 2	474 ft^3/ton	0-379 ft^3/ton	0-95 ft^3/ton
Heat Recovery	7 ft^3/ton	7 ft^3/ton	7 ft^3/ton
Cooling Tray	7 ft^3/ton	7 ft^3/ton	7 ft^3/ton
TOTAL	976 ft^3/ton (N_2)	407-786 ft^3/ton (N_2)	123-218 ft^3/ton (N_2)

Table II shows the preferred embodiment of the invention with the same operating conditions as in table I and thus same entries in columns 1 and 2. But, in this case, column 3 reflects the total amount of flow supplied to the deodorization trays, when the gas supply to each tray is turned on in the pulsing sequence of 60 seconds on followed by 180 seconds off.

This sequence is repeated for the duration of the oil in the deodorization trays and may be applied to one tray or to two or more trays. Where two trays are in use, inert gas supply alternates between the trays at a set switch time interval so that both trays are not supplied with inert gas simultaneously, supply to one tray is turned on while supply to the other tray is off.

The process may be run as in Table II to achieve the required deodorization of the edible oil. The total requirement of 123-218 ft^3/ton inert gas flow rate is within the range of actual amount of nitrogen required to remove the impurities from the oil as disclosed in the '092 patent. The present invention, using the pulsation technique, allows operation of the umbrella tray even at this considerably reduced flow rate of inert gas.

Yet a further reduction (not shown in the tables) may be achieved by raising the static level of the oil in the collector. This reduces the distance to which the oil must be lifted by the inert gas to reach the top of the tray and thus also reduces the required flow of inert gas. However, this change in static level may result in a decrease in mass transfer, since the distance the spray travels is reduced from where it leaves the umbrella of the tray to return to the static level in the collector. Even with this reduction, the deodorization result is still better than when steam is used since the mass transfer is far better with nitrogen than with steam.

Specific features of the invention are shown in one or more of the drawings for convenience only, as each feature may be combined with other features in accordance with the invention. Other embodiments will be recognized by those skilled in the art and are within the scope of the claims.

Claims

1. A process for reducing the quantity of inert gas required to deodorize crude edible oil, in a deodorizer having at least one deodorization chamber, comprising: supplying an inert stripping gas to said chamber intermittently to contact the crude edible oil, thereby removing impurities from the crude edible oil to deodorize it, and recovering the resulting deodorized oil.

2. The process according to claim 1, wherein the deodorization chamber includes at least one gas-lift umbrella type tray, and the crude edible oil has a residency period in said umbrella-type tray.

3. The process according to claim 2, wherein the inert gas is intermittently supplied to the umbrella-type tray at timed intervals so that when the supply is on and inert gas is flowing to the umbrella-type tray, the flow rate is sufficient to operate the tray, and the total amount of inert gas supplied to the umbrella-type tray during the residency period is greater than or equal to the quantity of inert gas required to deodorize the oil.

4. The process according to claim 3, wherein the inert gas is intermittently supplied to the umbrella-type tray at timed intervals of about 0.5 to about 3600 seconds.

5. The process according to claim 3, wherein the inert gas is intermittently supplied to the umbrella-type tray at timed intervals of about 30 to 60 seconds on alternating with 30 to 180 seconds off.

6. The process according to claim 2, wherein the inert stripping gas is introduced to the chamber in an amount substantially less than the theoretical requirement for deodorizing the edible oil and wherein the inert gas flow rate is sufficient to operate the umbrella-type tray.

7. The process according to claim 1, wherein the deodorization chamber has a first gas lift umbrella-type tray and a second gas lift umbrella-type tray.

8. The process according to claim 7, further comprising: apportioning the intermittent inert gas supply to the deodorization chamber between the first and second umbrella-type trays.

9. The process according to claim 8, wherein the inert gas is supplied alternately and consecutively, at a set switch time interval, to the first and second umbrella-type trays so that when the inert gas supply is turned on to the first umbrella tray, it is turned off to the second umbrella-type tray.

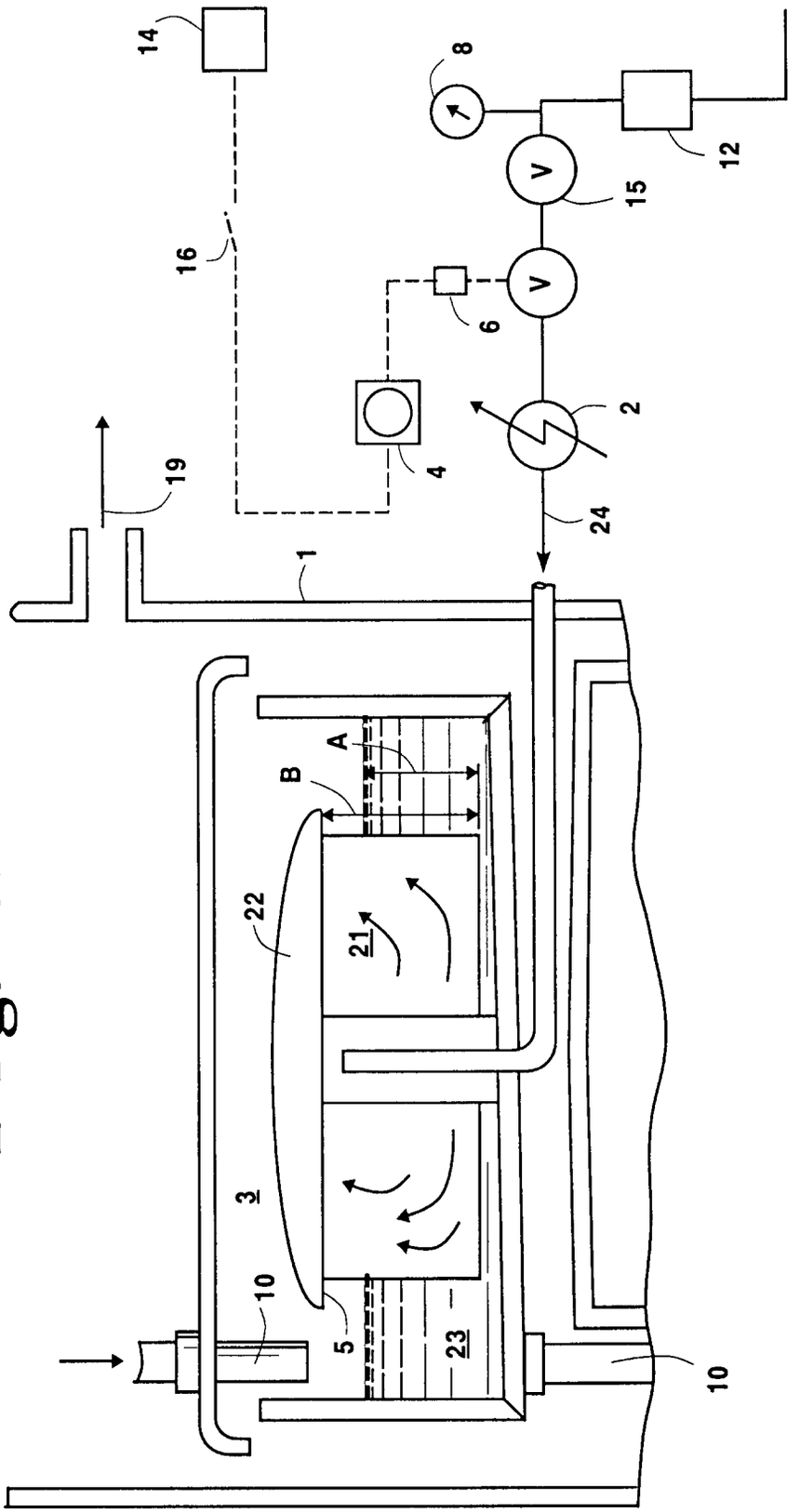
10. The process according to claim 9, wherein the intermittent supply of the inert gas to each umbrella-type tray is at timed intervals so that when the supply is on and inert gas is flowing to one of the umbrella-type trays, the flow rate is sufficient to operate the tray, and the total amount of inert gas supplied to the umbrella-type tray for the duration of the oil in that tray is greater than or equal to the quantity of inert gas required to deodorize the oil.

11. The process according to claim 7, wherein the inert gas supply to the second umbrella-type tray is completely turned off, such that the inert gas is only supplied intermittently to the first umbrella-type tray.

12. The process according to claim 1, wherein the inert gas is a non-condensable gas such as nitrogen.

13. The process according to claim 1, wherein the inert gas is introduced to the deodorizer at a flow rate in the range of about 123-218 ft^3/ton edible oil processed.

Fig. 1



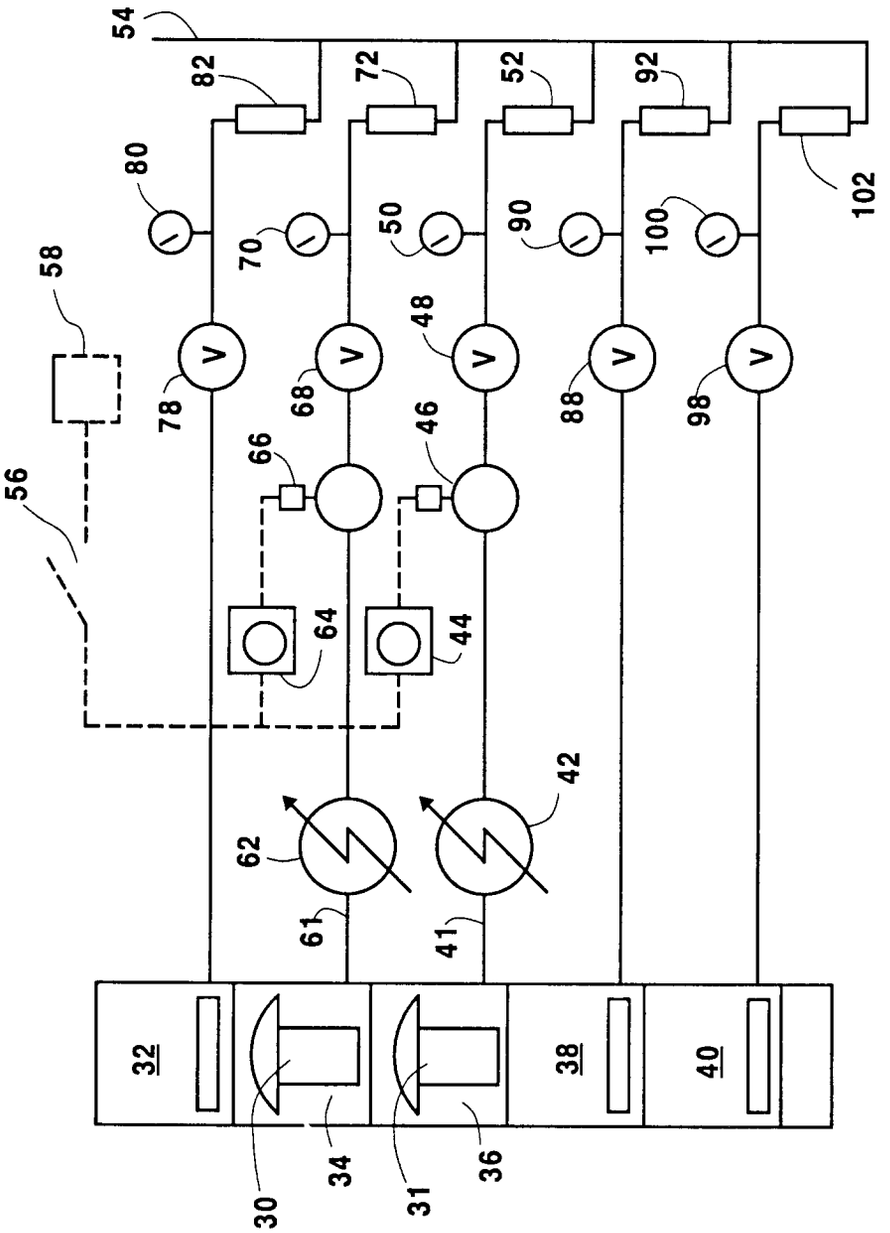

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Fig. 2