NEW PLANT FOR FAT EXTRACTION BY SOLVENTS

Although the extraction of oil from seeds by solvents is theoretically very simple and desirable, solvent extraction has not obtained the vogue to which its inherent advantages entitle it. This is due to the coincidence of several disadvantages each by itself not of the utmost importance but taken together producing a total effect which has created a certain lack of favor. In fat extraction, as in every other commercial process, the net result desired is a profit. As oil extraction is fundamentally an intermittent process, various factors enter into the final cost such as the time spent in charging and discharging, the amount of labor spent in completing a cycle, the size of the individual charges, the amount of superintendence necessary, the cost of fuel, power, etc., the quality of oil obtained and the nature of the exhausted cake. In other words, the problem is essentially one of chemical engineering. Wherever it is possible to conduct the necessary operations mechanically instead of by hand labor, where the operations can be fitted in so that an efficient use of whatever labor is required is achieved, and where the method of operation is such that there are no considerable idle periods for any parts of the plant, considerable economy is obtained.

In the past, attempts toward economy have generally been in the direction of increase in unit size. A 3 or 4-ton extractor has required 6 to 12 hours for a complete cycle with a considerable period between cycles for discharging the extracted meal and recharging with fresh crushed meal. The use of labor is generally unevenly distributed so that economy is difficult, dilute solutions are also obtained which tend to complicate the process by the use of these final weak solutions to extract new charges and large volumes of solvent must be distilled to obtain the oil. In addition both the meal and the oil must be rendered free of solvent involving in some cases open steaming of the meal for several hours and dry and wet distillation in the case of the oil. This latter may in turn require the use of considerable condensing surfaces.

The battery system of operation does away with the distillation of large volumes of dilute fat solutions but the battery system can be used only for installations of considerable size. In general the use of agitators has been given up as ineffective and introducing unnecessary complications except for the purpose of assisting in the discharge of the extracted meal. All the above considerations are indicative of the economic disadvantages of attempting to run a solvent extraction plant. In addition there is the very serious disadvantage that the long period of time in which the materials are subjected to heat and moisture causes considerable hydrolysis of the fat with a considerable consequent lowering in value of the extracted oil due to the presence of free fatty acids. Prof. J. W. Hinchley in an address before the joint meeting of the Institution of Chemical Engineers and the Oil and Color Chemists' Association at the Congress of Chemists held at London, July 23, 1926, described a new type of plant which has overcome many of these difficulties leading to an operation which is more economical of labor, fuel and power and yielding a product of such high quality that it is extremely probable that a revolution in the solvent extraction of fats will be accomplished thereby. Before describing in detail the exact structural features of the plant, a few remarks about the nature of the process will be made.

The plant is very small in size so that it never contains more than 400 pounds of material at a time although the output in 3 to 4 tons per 8-hour shift. The total time of extraction is approximately 30 minutes and the total time of steaming off the meal to free it from solvent is only 4 to 6 minutes. These rapid operations are accomplished by the peculiar method of treatment, by pre-heating the meal to nearly the temperature of the steam and by the fact that the steam has to pass through only a few inches of material instead of through several feet as in the usual type of plant. The stills are required to take care only of solvent well saturated with oil and the distillation of oil solution is continuous. The time of heating both the meal and the oil is reduced to a minimum.

It has long been understood by chemical engineers that heavy solvents such as trichloroethylene possess a great advantage in that the extraction can be made by upward flow of the solvent. As a rule by the use of a heavy solvent allowing it to rise through the meal and overflowing above to the extent of about half the volume of the meal itself and then draining a satisfactory extraction can be made. However, solvents such as trichloroethylene introduce problems of corrosion and affect the health of the workers so that they have not become popular. The plant devised by Prof. Hinchley is so small in size and of such a design that the use of special resistant metals and of a design which prevents loss of vapors and thus obviates any injury to the workers' health becomes possible.

With light solvents several flushes are required to produce satisfactory extraction. Since the amount of oil removed by each flush depends upon the ratio between the total solvent used and the amount retained by the meal after drainage considerable quantities of solvents are required in the plant. Thus for a unit treating 3 tons per charge, 7 tons of solvent will be necessary in the plant. In the equipment to be described, although the weight per charge is small, for an equal output, namely, 3 tons in 8 hours, not more than one ton of solvent would be required. These results are possible because small quantities of material are dealt with, the rate of solution of the fat is high and the removal of solvent from the meal is thorough. The solvent feed pipes are large, continuous agitation with the solvent takes place, the depth of the charge is only a few inches, and the

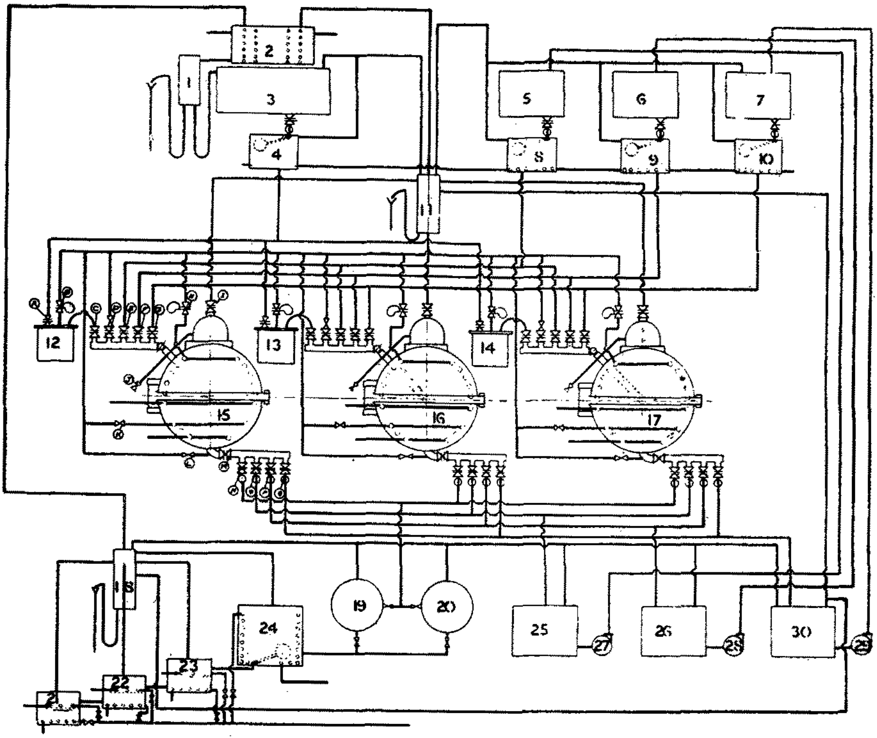

Fig. 1. Showing the Arrangement of the Plant

Drawing from Chemistry & Industry

operation is conducted in a rotating cage so that the amount of liquor left in the meal on drainage is very small. The cage or basket which contains the meal is a perforated drum the axis of which is a hollow shaft through which the steam and solvent are supplied. It rotates at different speeds in different parts of the operation. The charging is carried out by the removal and replacement of one of the end plates of the cage and the cage is inserted into a cylinder which contains the necessary gear for rotating it.

After the cage is placed in the cylinder, a valve control permits the entry of steam and the driving out of most of the air from the cylinder. Each unit consists of 3 cylinders with their cages, each one being operated separately. After the operation of charging and discharging automatically hydraulically controlled valves operated by means of a timed cam shaft control the operation of the various valves during the process. This cam shaft controls all the operations from the supply of the solvent until extraction and steaming are completed. The cam shaft makes one

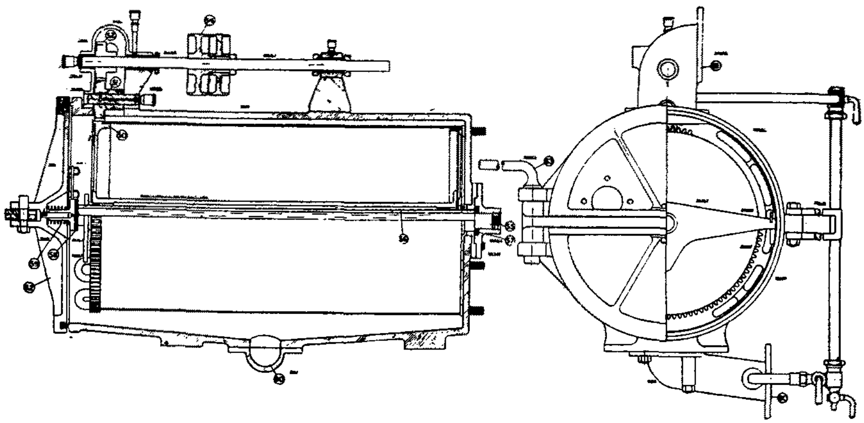

Fig. 2. The Cylinder with the Cage in Position

complete revolution in 32 minutes and has 16 movements, making each movement 2 minutes long. By means of a special control the operator, after ejecting most of the air from the cylinder as described above, throws a lever by which the cam shaft takes over the operation of the plant. At the end of the 32-minute cycle the machine stops and a signal tells the operator that the extraction is complete and that the cage containing the extracted meal is ready for removal. Although each of the 3 cylinders operates independently of the others, the solution tanks and the solutions are dealt with together. In addition to the 3 treating cylinders the apparatus contains a condenser and separator, solvent tank, solution tanks, measuring tank, solution measuring tank, and distilling equipment.

On the operation of the cam shaft the cage commences to rotate and a highly saturated solution of fat, which is called solution No. 3 enters the cylinder of the slowly rotating cage and the solution obtained runs off for distillation. No. 2 solution now enters the slowly rotating cage and is run off into solution tank No. 3. Solution No. 1 now enters and is run off into solution tank No. 2. At this point the speed of the cage is raised automatically and clean solvent enters and runs through the charge into solution tank No. 1 thus completing the extraction cycle. The cage continues to revolve at the higher speed but steam is admitted into the closed heating coils in the cylinder by which the temperature of the meal is raised to as near that of the steam as is possible. Direct steam is now admitted through the hollow shaft for 4 to 6 minutes at the end of which time the extraction cycle is completed and the apparatus stops. This method of operation produces a very highly concentrated fat solution for distillation. The highly concentrated fat solution is discharged into a regulating still which while it continuously evaporates the solvent by means of a closed steam coil converts the intermittent flow which it receives into a regular stream of liquid which enters a set of 6 small stills arranged in two parallel sets of 3 stills each. Each still contains a tray with an independent heating coil and partitions so that the liquid travels along the coil at a depth of only about ⅜ of an inch. The tray in the last pair of stills contains perforated steam coils for wet steaming and final

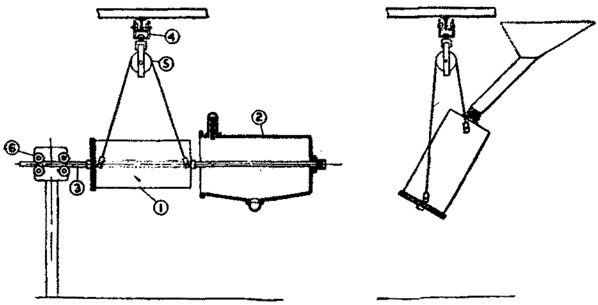

Fig. 3. How the Cages Are Charged and Discharged

removal of the last traces of solvent. The level of the liquid in the main body of each still is controlled by a constant level device by which the discharged liquid is taken from the bottom of the still while the level is maintained. The intermittent discharge of concentrated solution from the extraction plant is thus controlled to give continuous distillation and removal of the solvent from the oil. The attached figure 1 shows the arrangement of the plant. In this view the first stage of extraction is being carried out in cylinder 15. A consideration of this drawing shows how essential the automatic devices for the control of the various stages of the process are for the practical success of the plant. Obviously more cages are necessary than 3 to avoid delay during the charging period.

The operation of the machine may be considered as consisting of 7 stages:

1. Preliminary treatment of the dried meal with solvent vapor.
2. Extraction with strong solution of oil to obtain the rich solution for distillation.
3. A second treatment with fat solution which is used for operation 2 of the next charge.
4. A third treatment with dilute solution which is used for operation 3 of the next charge.
5. A final flushing with pure solvent.
6. A drying period when most of the liquid is expelled from the meal by rotation of the cage while being warmed with indirect steam.
7. Steaming with direct steam to remove traces of solvent from the meal.

During periods 1 to 5 the basket is rotating at low speed but sufficient to keep the meal constantly turning over and changing position so that no pockets or balls are formed thus accomplishing agitation without any agitator. During periods 6 and 7 the speed of the cage is increased so that the meal forms a cylinder with a wall of even thickness and texture as a result of which the steam used for driving off the last traces of solvent is able to operate effectively without any channelling occurring. As a matter of fact the steam actually displaces some of the final solvent without evaporating it owing to the uniform texture of the meal in the cylinder. The amount of fresh solvent used for each charge is only 16 to 20 gallons.

The process described involves a system for handling solutions of different densities at varying speeds of cage rotation for which hand control would have been ineffective. Figure 2 shows the cylinder with the cage in position. The rotation of the basket is effected by means of the fast and loose pulleys on top. The cover of the cylinder is closed by a clamp device similar to that used in the ordinary horizontal gas retort. Figure 3 illustrates the method of charging and discharging the cages. At the right a cage is being charged with meal. The end plate is then clamped on and it is moved to the horizontal position shown at the left and is entered into the cylinder. A number of experimental extractions have been carried out using a complete single cylinder plant of this type. A complete 3 cylinder unit is being constructed in England and another in Germany. From the data of the experimental work it is apparent that there will be no difficulty in operating successfully with any oil seed. The data show that steam and solvent consumption will be lower than in ordinary plants and the labor costs will be less through continuous employment. The extracted meal will be discharged in a dry condition which is highly advantageous. The oil is of extremely high purity. The linseed oil obtained has puzzled even experts. It is free from the normal smell of linseed oil, when heated it becomes very pale and on boiling develops no offensive odor.

Owing to the fact that only a small quantity of solvent is required, the range of solvents is increased and differential extraction by more than one solvent becomes a commercial possibility. The results with linseed oil indicate that this method can yield a solvent extracted product equal to the pressed product and that consequently all the prejudices against solvent extracted oil must disappear.