# Ramifications of the Oil Industry

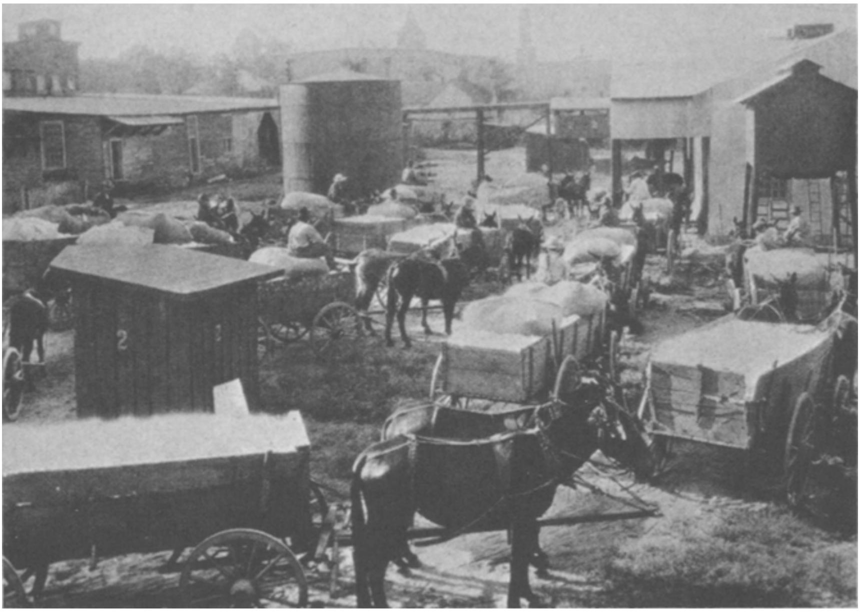
## (Part 1.) Processes.

BY THOMAS ANDREWS

THE raw material of the Oil and Fat Industries, as it is received into the mills, consists, essentially, of the oleaginous material from which the required oil or fat may be obtained, but with it we find various impurities of which the most important are:—

1. Moisture.
2. Dirt and adhering dust.
3. Metallic impurities.

After weighing the material at the mill, the first process consists of removing, as far as is commercially possible, these impurities from the bulk. Outweighing, in its possible effects, the other impurities is the moisture, because in the presence of the enzymes contained in the seed, this produces hydrolysis with a consequent formation of free fatty acids. Moreover, under favorable conditions of storage, oxidation of these and of the freed glycerol can take place. When it does we find an oil that is high in free fatty acids and rancid. Our first thought, therefore, must be directed to seeing that the seed is well ventilated, and stored under loose conditions as far as possible, as dry as possible, and so arranged that the maximum amount of air can circulate through it in the bulk.



Ewing Galloway

*Receiving Seed Cotton at a Southern Oil Mill*

In dirt and adhering dust removal we nullify the effects of the close confinement that our oily material has suffered in transit. Should it be desirable to remove matter larger than the seed, then the material is fed through revolving screens, the mesh of which will allow the seed to fall through, but not the larger impurities. A screen which will retain the seed and allow the dirt and dust to pass through is next used. When blowers are fitted to these screens a very valuable double effect is obtained although this is not always intentional nor recognized. I refer to the thorough ventilation that the seed obtains while rolling around in a screen through which a current of air is passing. Introduced in the first instance to thoroughly remove the dust and dirt, to allow the marketing of a pure cake, there is no doubt but that this thorough ventilation is of great value from the point of view of good quality oil.

The removal of pieces of iron and steel presents very little difficulty. Permanent magnets or electromagnets are placed in the path of the material prior to its entry into any machine and these metals are removed. There generally remains a small proportion of material approximating the seed in size that is removed only with difficulty. Generally, where desired, it is removed by hand during a portion of the seed's preliminary journey when it is thinly spread, as when traveling on a belt.

The purified bulk is then placed in silos for storage.

### Methods of Winning Fatty Values

We may classify the various methods of obtaining the oil or fat under the following headings:

1. Dry rendering.
2. Digestion with steam or hot water.
3. Expression.
4. Extraction with solvents.

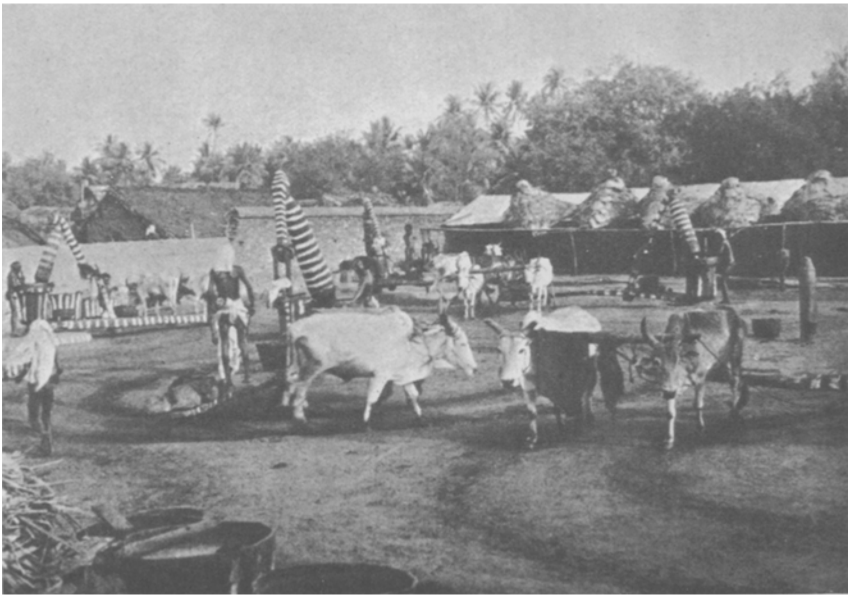
These processes are being worked in many ways. We still have instances of oil obtained by natives using the primitive methods of their forefathers competing with the same oil obtained by a staff of highly trained technicians working elaborate machinery under modern conditions.

In the case of those oils obtained from seeds and nuts having an outer shell or covering, it is often necessary to remove this covering before the operation to recover the oil can be used. In the removal of these coverings there are great obstacles to be overcome and a great deal of ingenuity has been expended in designing machinery for this purpose. There is no doubt but that the oil trade has progressed as and when machinery has been adopted to do this work. Without the invention of the "linter"—a machine for removing the fine cotton fibre adhering to some classes of cottonseed—the present American cotton oil trade might have languished and possibly even perished instead of becoming the leading cottonseed trade of the world. These coverings vary considerably and, as a corollary, no one machine can handle the whole, but must be, and is, designed to carry out one particular work. For example coconuts have to be freed from a thick, hard, hornlike cover, and the groundnut, after it has been shelled in one machine, has still a thin, tissue-like, soft skin that is often removed. Between these two we have practically every type of covering to remove, requiring much time and effort to design machines to carry out this work.

Having removed the outer covering from the oil-bearing material the next process consists of preparing the kernels or "meats" for the recovery of the oil. Those materials the next process for which consists of rendering or digesting are minced to a moderate fineness, and nothing more, the heat and moisture incidental to the process being allowed to break down the tissue holding the oil cells. With those materials however that are to be pressed or extracted, the oil cell is broken down. To do this the "meats" are subjected to very fine rolling and grinding accompanied by a tearing action. The "meats" to be pressed are further treated with heat and moisture—tempered, as it is called—to further break down the oil cells, with the result that the oils are freed from the container in which nature has placed them and are consequently more easily removed by pressure.

Dry rendering is chiefly used in connection with animal and fish tissue whenever oil forms the bulk of the raw material and whenever the moisture content is high enough to cause a breakdown of the fat cell on heating. This applies to suets, meat fats, blubber, bones and to certain fresh fish livers.

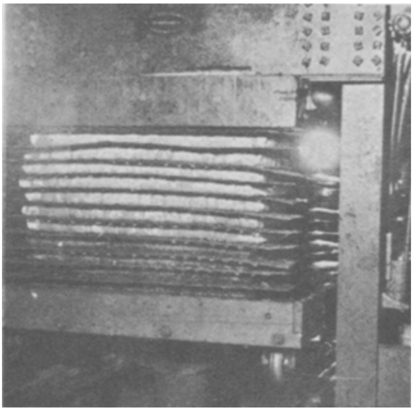
Digesting either at high or low pressures is resorted to in the case of similar material as is used in rendering, in those cases where hydrolysis is not of paramount importance. Digesting differs from rendering in that water, in some form or other, comes into intimate contact with the fatty material. The product is of a lower grade than that obtained under a first class dry rendering process but the process has certain well defined advantages. In the case of putrefied animal and fish tissue it is often the only commercial method of obtaining the oil or fat in a marketable condition, for it is possible by this method both to obtain the oil and at the same time



*Ewing Galloway*

*Primitive Methods of Pressing Sesame Seed in India* partially deodorize it. This is accomplished by digesting at high steam pressures and by releasing the pressure at stated intervals during the run. This method is also resorted to in obtaining the oil from palm fruit, and a melange of pressing and digesting is often used in the manufacture of inferior olive oils. In both the above processes the oil is removed by skimming the surface of the mixture left after settling. In the case of dry rendering, the tissue lies at the bottom of the pan as a somewhat moisture free mass containing up to 50% of fat. This material is treated in a press to remove the bulk of the remaining oil or fat and the cake is sold for poultry feeding or similar purposes under the name of greave cake. In the case of digesting, the residue consists of a wet mass of tissue and fibre which is generally dried to produce meals for fertilizers.

Expression consists of exerting power in such a way that the liquid oil is expelled from the solid matrix. The hydraulic press is the machine most commonly used for this purpose. It consists essentially of a ram that rises within a cylinder when acted upon by a fluid under pressure. In rising it is made to transmit its pressure to material between it and a fixed plate. In the older forms of presses the pressure under the ram was transmitted to a series of plates free to rise with the ram and containing between each pair an envelope filled with the "meats" to be treated. The oil that was pressed out ran down into a gutter from which it was carried to the store tank for further treatment. The cake was removed from the press in its envelope. This was removed and, after the oily edges of the cake had been peeled away, the cake formed the chief source of the majority of cattle foods and fertilizers of vegetable origin. A more modern form of the hydraulic press is that one in which the envelopes are not used, a finely divided or perforated box or cage taking the place of them and extending for the full space between the ram and the head of the press. The comminuted tempered meal is placed within the box or cage in definite charges and metal plates are used to divide each charge, thus doing away with the envelopes. Pressure is applied direct to the charges within the cage. The oil is discharged out of the minute divisions or perforations. The cakes from this type of press do not require paring of their edges, although they are similar in other respects to the cake obtained from those presses using porous envelopes. As the pressures which can be applied to the cake in this form of machine are often very high, we find that in the endeavor to obtain very good yields of oil some crushers are in the habit of turning out a hard cake. Consequently, from a cattle feeding point



*Ewing Galloway*

*Pressing Seed Oil in the Pribilof Islands* of view, these cakes are considered inferior to the others—but there is no reason for their being so.

The screw press in which the action of a worm propeller presses the meal against some obstruction, thus accumulating the pressure, also is used for removing the oil, which flows through minute orifices in the worm box. This is built in a similar manner to the cage of the latter type of press considered above. It yields a meal and an oil as against a cake and an oil in the case of the press. With these expellers, however, there is generally a comparatively large proportion of foots. These consist of a suspension of very fine meal in oil, and owing to the fact that the meal is practically in colloidal suspension in the oil, its separation is a very difficult problem. In such a foots obtained when treating groundnuts the oil content exceeded 45%.

Solvent extraction, as its name implies, is a method used for removing the oil by dissolving it out by a solvent, leaving the solid material behind. The material to be extracted, in a properly pulverized condition, is fed into a closed tank through a suitable charging door. The door is then closed and the solvent is passed into the meal in such quantities that there is a considerable surplus over the amount needed to saturate the meal. After the solvent has remained for a short time in close contact with the meal, this surplus is withdrawn and the remaining meal is washed with further quantities of solvent until the oil content has been removed to the requisite amount. The solvent containing the oil is removed to a still where the former is distilled off leaving the oil behind. The solvent is passed as a vapor through a series of condensers where it is recovered for further use. The solvent saturating the meal is removed by open steam, condensed, and after being separated from the water, which is condensed with it, is returned to the store tank with the solvent from the still. The oil in the still is freed from traces of the solvent by open steam, and both it and the meal are discharged. The meal, after drying, is used for the same purposes as the cakes from the press, although owing to its lower oil content certain modifications have to be allowed for.

### Uses of the Products

By using one or more of the above processes we have our oil free from solid meal and our meal free from liquid oil. As we have seen, the solid material, irrespective of the method adopted, may give us either a fertilizer or a cattle cake or meal. The origin and condition of our raw material largely determines the final use of the residue—foods in the case of the non-injurious and fertilizer in the case of the putrid or poisonous. When it is desired to use these materials as fertilizers they are finely ground, but the cakes to be used for cattle food may be sold in the condition in which they are received from the presses. The meals which contain too high a proportion of moisture to meet the market conditions are dried in some form of drier. To market the meal for cattle food, other than for feeding pigs, it is usual to further treat it in some way so as to make it more easily and efficiently fed to the animals. With this further operation it is usual to arrange such blendings and additions to the meal as will make the food more balanced or more appetizing. The meal is fed into a kettle similar to that used in heating and tempering for pressing and, while it is being treated, the whole is agitated with such spices, sugars, binding materials, diluents or additive materials as will, in the opinion of the blender, give the desired food. The whole is then thoroughly mixed and warmed, the warming or cooking having the twofold object of bringing the starchy material into a "binding" condition and of liberating the cyanogen radical from the glucocyanides that are present in some seeds. The material is then forced by pressure either into moulds or through dies where it forms a convenient and handy form of cattle food in the shape of nuts or cubes.

With *oil* containing a more or less high proportion of meal it often is necessary to remove the solid impurities at the earliest moment, and in the case of those oils which are to be used for edible purposes *no time should be lost* in doing this. In some mills this is done by settling in tanks or by centrifuging, but in most modern mills the oil is filtered as soon as it comes from the presses or other plant. This oil constitutes the raw or crude oil of commerce.

### Classifications of Oils

These oils, for our purpose, may be classified into three main divisions:—

1. Drying oils, namely those oils which are capable of absorbing oxygen from the air and forming more or less elastic skins when exposed in thin layers.
2. Semi-drying oils, namely those oils which, while still capable of absorbing oxygen from the air, do so to a modified extent and are not capable of forming a firm skin under normal atmospheric conditions.
3. Non-drying oils, namely those oils which do not absorb oxygen from the air under normal conditions and which are not capable of forming a skin.

These definitions are more or less fixed by common usage in the chemistry of oils, and although they are open to serious objection from many points of view I will use this classification on which to base the uses of the oils from a process point of view.

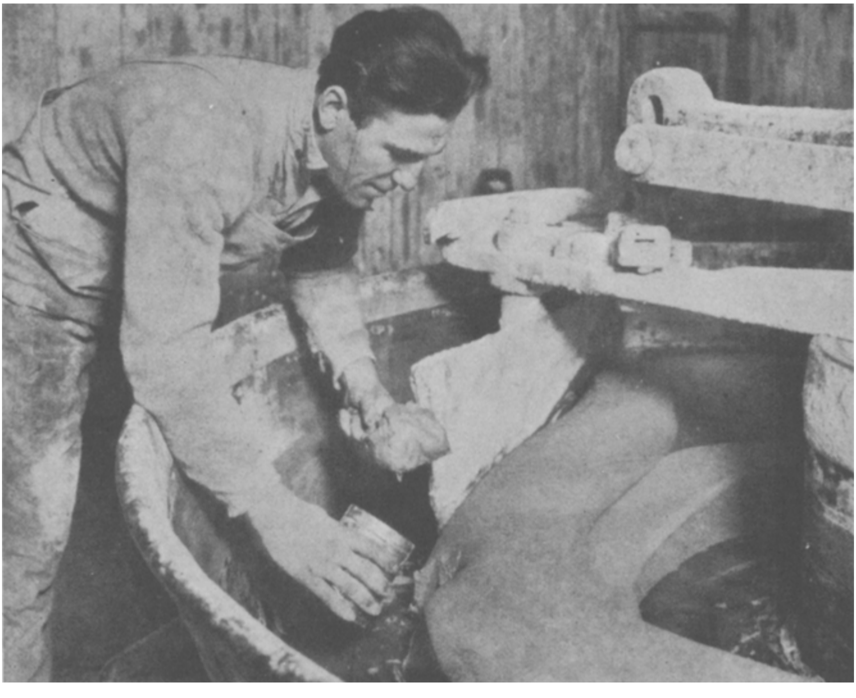
### Uses of Drying Oils

As the name implies the chief use of the drying oils is to prepare products capable of forming a skin. These oils will form a skin when exposed to the air without any preliminary treatment but in the desire to speed up this process of oxidation we have the foundation of the "boiled oil industry."

In the latest methods the oil to be "boiled" (quite a misnomer by the way) is heated to a temperature of about 150°C together with a small proportion of lead or manganese salts—the so-called driers—with or without the passage of an air current, the length of time that is taken determining the quality of the oil both with regard to its color and its drying properties. The peculiar reaction that occurs causes the oil to skin when laid in a thin film in hours instead of in days as a thin layer of the raw oil would need. The actual *modus operandi* of the process is simple but the underlying reaction is not fully understood to this day. At one time it was thought that the speeding up was due to the absorption of the oxygen during the boiling of the oil but as oils can be prepared, after boiling, with the same iodin value as they had previous to the boiling, this view cannot be accepted. The view that in the boiling the metallic driers become converted into metallic soaps which act catalytically in the drying of the boiled oil is still open to proof because if we add lead linoleate (the salt which would be formed on boiling convertible lead salts with commercial linseed oil) to linseed oil in the cold the resulting oil is not speeded up as would be the same oil on boiling. Moreover this oil with the addition of the salt *is* speeded up if we raise its temperature to something over 120°C. Personally I subscribe to the view that a small proportion of a polymer is formed—possibly crystalline—capable of being itself oxidized and creating a further supply of polymer in so doing. To make this perhaps a little clearer I would refer to the oxidation of coal. Coal is capable of burning (oxidizing) and at the same time it is capable of bringing raw coal in its immediate neighborhood into a condition for rapid burning or rapid oxidation. This analogy, while not perfect, will give you some idea of the automatic oxidation which takes place. Linseed oil is practically the only oil which lends itself to the process of boiling although other oils of high iodin values can be, and sometimes are used, but unless the high iodin value is associated with the presence of an appreciable amount of linolenic acid in the oil it cannot truthfully be said that the oil is a "boiling oil."

It is usual to refine the linseed oil that is to be boiled, to remove the mucilage, organic salts, moisture and other impurities which might otherwise spoil the oil during the process of boiling. This is particularly important in the case of those boiled oils which are to be used later for mixing with gums at high temperatures to form varnishes. The boiled oils find a ready outlet in the manufacture of paints, varnishes and enamels. A paint is, essentially, a levigated pigment ground in boiled oil to a homogeneous mass free from grit. To prepare this paint for application this ground mass is thinned out with more boiled oil, turpentine and, in some cases, with petroleum products. In the case of paints the pigments are not in solution in the boiled oils and this is the chief difference between a paint and a varnish. A varnish consists of a gum or resin dissolved in boiled oil. Gums in their raw state, do not dissolve readily, if at all, in boiled oil. After fusion, however, at temperature of 300°C and over their solution in boiled oil, while still brimming with difficulties, can be accomplished. Thus the first operation in the manufacture of varnishes consists in heating the gums to such temperatures as to make them soluble in the boiled oil. During the heating the gums lose weight and the manufacture of varnishes, from the efficiency point of view, largely consists in heating the gum to the soluble condition with a minimum loss in weight. After the solution of the gum in the boiled oil the varnish oils are settled or filtered. They are then thinned by the addition of oil of turpentine till they are in the right condition for applying. This addition of turpentine is likely to cause a fog or a bloom in the varnish unless the gum and the boiled oil are in the right condition. If, instead of thinning the varnish oil, pigments had been ground into it, the well known enamels would have been formed. These are thinned in the same way as paint for use.

When we come to consider the action of air and heat on the semi-drying oils we find that they can be oxidized as well as the drying oils but they yield a different class of products. These are the well known soluble, thickened or blown oils. Air is blown into the raw semi-drying oil as a fine spray, the oil being kept steady at the predetermined temperature, generally between 75°C and 110°C. At the same time the air is kept in motion in some manner so that intimate contact is made between the oil and the air. As the absorption of the oxygen is accompanied by evolution of heat it may be necessary to keep the temperature of the oil from rising during the reaction. During the reaction the oil rises in specific gravity and attains a high viscosity. At the same time volatile decomposition products are given off which require to be removed as in the presence of absorbent material they are likely to cause spontaneous combustion. Owing to their high gravities, high viscosities and miscibilities with mineral oils these are sometimes sold under the name of "soluble castor oil" although they have no relationship to castor oil at all. They can, however, be easily recognized from castor oil owing to their very poor solubility in alcohol.



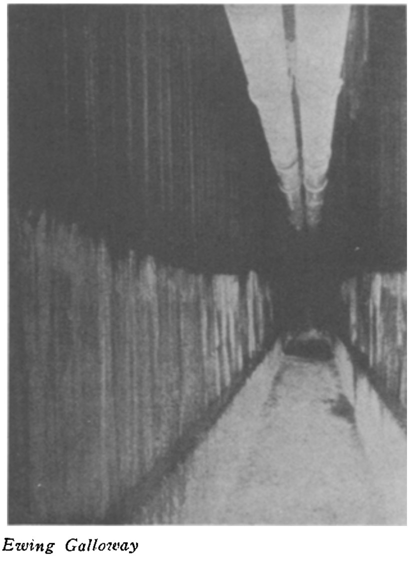
*Ewing Galloway*

*Mixing Putty in Which Linseed Oil is the Base*

The oils which are chiefly used in this process are rape, cottonseed, maize, seal and whale oils. The oils, where necessary, having been freed from the solid tri-glycerides by a process that I hope to refer to later, the blown oils are used (blended with mineral oils) for lubricating purposes although their tendency to gum and their low flash points preclude their use under certain conditions. The blown oils also find a use in the leather-curing industry, in fact, at one time this was their only outlet.

### Linoleum Manufacture

If instead of blowing the semi-drying oils we had started with linseed oil, or better still, blown linseed oil we should have found that this oil behaves in the same manner and is capable of absorbing large quantities of oxygen and, if we had carried the experiment far enough, we should have found that at ordinary temperatures the product was quite solid. This oxidized boiled oil is prepared on a very large scale commercially and forms the body for the preparation of linoleums. The linseed oil is oxidized in a variety of ways the best of which is known as the "scrim" process. Here the boiled linseed oil is allowed to flow at a moderate temperature down a layer of fine cotton fabric suspended in a lofty building and the oil reaching the bottom is re-circulated over and over the fabric until it gives a thick layer of solidified linseed oil on either side of the fabric. The solidified oil can be made in a plant similar to that used in the blowing of the semi-drying oils but the resulting product is considered inferior to that produced by the "scrim" process. This solid oil mixed with varying proportions of kauri gum, cork dust, resins and similar material (with various bodies and pigments) backed on to a jute fabric forms the "floorcloths", "linoleums," "cork linoleums" and similar substances that are so well known to all of my readers.



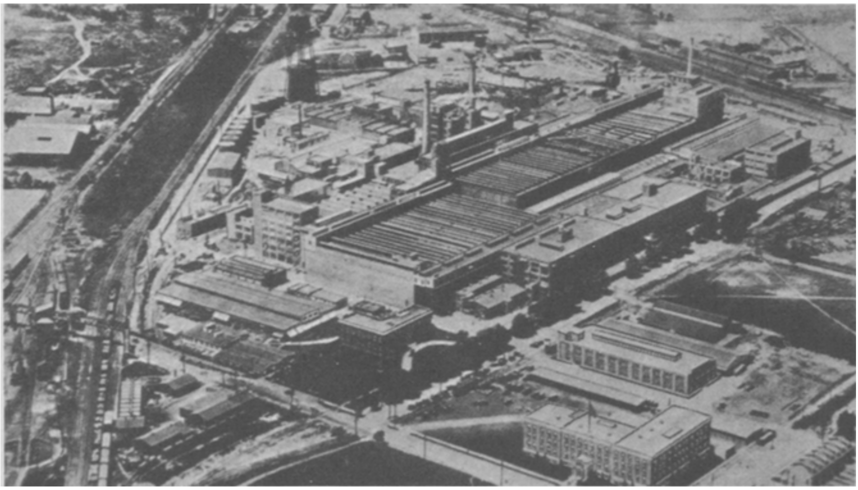
*Ewing Galloway*

*Interior View of Linoleum Oxidizing Tower*

The close resemblance that sulphur bears to oxygen—chemically—will no doubt have caused some of you to wonder whether the above reactions between oils and oxygen have their counterparts with oils and sulphur. Surveying the chemical reactions of oxygen and sulphur with the same bodies we can formulate the general rule that sulphur will react similarly to oxygen but at a slower velocity. This rule holds true in the oil world. Where the reaction of oils with oxygen are rather violent, the reactions with sulphur, if I may use the word, are dignified, and where oxygen does actually clutch the body with heat, sulphur will just shake hands as it were. Therefore as we may expect at elevated temperatures sulphur forms analogous bodies with oils to the various oxidized oils. These bodies are solid and semi-elastic and can therefore be used as substitutes for rubber. The oils most suitable for this process are rape, maize, sesame, and soya.

Looking over the above, we find

the processes that we have considered up to this point are all additive processes, that is to say processes where something is actually added to the oil molecule without destroying the molecular structure. Under this same classification we may include the hydrogenation of oils, or, as it is more commonly called,. the hardening of oils. As you must all be aware had we added oxygen to the oil in such a way as to destroy the structure of the oil we should have burnt the oil and our final products would have been carbon dioxide and water. As you well know some of the acids in the fatty acid world have some of their carbon content in a condition in which it can make an alliance with one or more atoms of another element without in any way upsetting the structure of the compound and without disturbing its own position in the linkage. As the normal element that should be present in these positions is hydrogen those carbon atoms which have not their complete number of hydrogen atoms attached to them are said to be unsaturated. If we can arrange to give these atoms their full complement of hydrogen we are said to have saturated the compound. This is what we do in the hydrogenation of oil. As the saturated oils and fatty acids are solid at ordinary temperatures, the term "oil hardening" has consequently arisen.



*Ewing Galloway*

*Aeroplane View of a Large American Linoleum Factory*

Oil and hydrogen in their ordinary condition have no great affinity for one another but by bringing an unsaturated oil and hydrogen together in the presence of a catalyst we can cause the hydrogen to fill the vacant positions in the carbon bondings. On a works scale the hydrogen is brought into intimate contact with the oil in the presence of finely divided nickel which has been freshly reduced from its oxide. Under these conditions the hydrogen penetrates the molecule and a saturated molecule is obtained. The degree of complete saturation will depend on the proportion of carbon atoms which receive their full numbers of hydrogen atoms, thus by varying the proportion of hydrogen absorbed we can obtain fats of varying hardness.

Practically all the unsaturated oils are suitable for hydrogenation although, price being equal, it will pay better to saturate those which will absorb the less quantity of hydrogen for a given hardness. Whatever oil of the unsaturated series we start with, we must finish with oils containing only the "stearic acid" group if we continue the saturation to its final end. In ordinary terms then our final product will be something in the nature of mutton tallow. These tallows, being largely the product of the animal kingdom, are limited in nature, whereas the oils of the vegetable world are abundant, and in that we are able to make the less abundant from the more abundant lies the value of oil hardening. As a natural corollary it follows that as the animal fats become scarcer so the value of hydrogenated fats must increase. Since there are no natural oils or fats with an iodin value of zero it is possible to hydrogenate all of them. These products find an outlet in the edible oil trade, the soap industry and in the candle industry.

### Substitutive Reactions

Passing from this survey of the oil industry as far as the additive products are concerned we come to that part of the industry where we add some body to the oil at the expense of a body already forming part of the oil. Oils are essentially "organic salts" or to give them their proper name "esters." A true oil is the ester of the alcohol "glycerol" and one of the higher fatty acids. When the fatty acid is in combination with another alcohol that ester is termed a wax. Glycerol is a tri-hydric alcohol and therefore combines with three molecules of the fatty acid to form the neutral oil. Following the usual law of chemistry it should be an easy matter to displace the glycerol radical by a stronger base and thus form a salt of the fatty acid. This is done commercially on a very large scale and is the principle underlying the manufacture of those commodities we call "soaps." From the above definition it will readily be seen that technically a soap is a combination of a fatty acid and a base but in common parlance we refer to the water soluble combinations only as soaps. The soaps of this class are the salts of sodium, potassium and ammonium with any of the higher aliphatic acids. The fatty raw material can be furnished by any of the natural occuring oils and fats or by fatty acids obtained from them by a preliminary treatment by other processes. The oil and the base must be selected with great care as no two oils or fats give the same identical soap and the choice of the base determines whether the soap will be "hard" or "soft." Potassium soaps are invariably soft soaps and sodium soaps are invariably hard soaps, but here again all soaps of potassium are not equally soft and all soaps of sodium are not equally hard. Broadly speaking, whatever base is used, the softness of a soap is in direct relationship to the iodin value of its constituent oils; the higher the iodin value the softer the soap.

There are two chief soap-making processes in use today on a manufacturing scale, called respectively; the "hot process" and the "cold process." There are certain classes of fats belonging to the coconut oil group which readily combine with caustic soda with the elmination of the glycerol to form a soap at low temperatures. Provided great care is taken it is not a difficult matter to prepare these soaps quite neutral, or a trifle superfatted, containing the requisite proportion of water to form a standard commercial article and many of the so-called "marine soaps" are so formed. These soaps when made from the coconut oil group are soluble in salt water and thus their name. However it is fairly obvious that in a process of this kind the glycerol content of the oil is lost which seriously bars this method of soap making from competing with the "boiled" soaps in spite of the low initial cost of the plant. At first glance it would appear that this cold process would be the ideal one for the combination of caustic soda with the *"free fatty acids"* but it is found in practice that lumps of soap from which occlude the fatty acids and that it is possible to have a cold process soap made from free fatty acids and caustic soda in which both the base and the acid are lying together in an uncombined condition.

*(To be continued)*

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## Fish Meal a Growing Industry

HAVING its origin in the war-born desire to conserve, the fish meal industry today is steadily growing and assuming an important place in the animal food trade. Norway ranks first in production, having more than 100 factories, and the United States is second with plants operating along both the Atlantic and Pacific coasts.

The disposal of fish refuse has always been a problem among fishermen. Every net load brought to the surface by them contains many varieties not suitable for man, and of those that find their way to the markets of the world, about forty per cent is waste. Before the war this large supply of refuse was reduced to fertilizer, but through the impetus to conserve created during that time, ways were found to prepare it for feeding to animals.

From storage tanks or ships' holds the fish that supply Norwegian factories are carried in a series of cups on an endless chain into boilers where they are sprayed with steam. A conveyor pulls them through the boiler and from the other end they emerge as a warm pulp. This is pressed and dried and ground into meal. In another process the fish are salted, allowed to season for ten days and then cooked by steam and pressed into cakes. These are broken up and dried in heated cylinders and later ground fine and sifted.

Although Norway and the United States are the largest producers of fish meal, Germany is the greatest user, feeding 100,000 tons a year to swine. The meal is given in large quantities to young pigs, the amount being decreased as the animals grow older and being discontinued entirely a few weeks before slaughtering. This method of feeding is necessary to prevent the meat from having a fishy flavor.

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## Miss Walker Joins Bureau

Miss Geraldine Walker, formerly research associate for the American Oil Chemists' Society at the U. S. Bureau of Standards, became a regular employee of the Bureau on July 2. Miss Walker is expected to continue with her work on the standardization of Lovibond glasses.