DESIGN AND OPERATION OF A SOLVENT EXTRACTOR PLANT

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In the previous paper "The Practical vs. the Theoretical Side of Oil Extraction," the conclusion was drawn that the moderate sized extractor of 5000-6000 pounds capacity per charge, without any movable parts such as agitators or circulating pumps, and which was not inter-connected with any other unit, in its main functions, was commercially the most practical type.

This paper will describe the method of operation of each unit of an extractor of this design, and the points of importance in laying out an installation of several units.

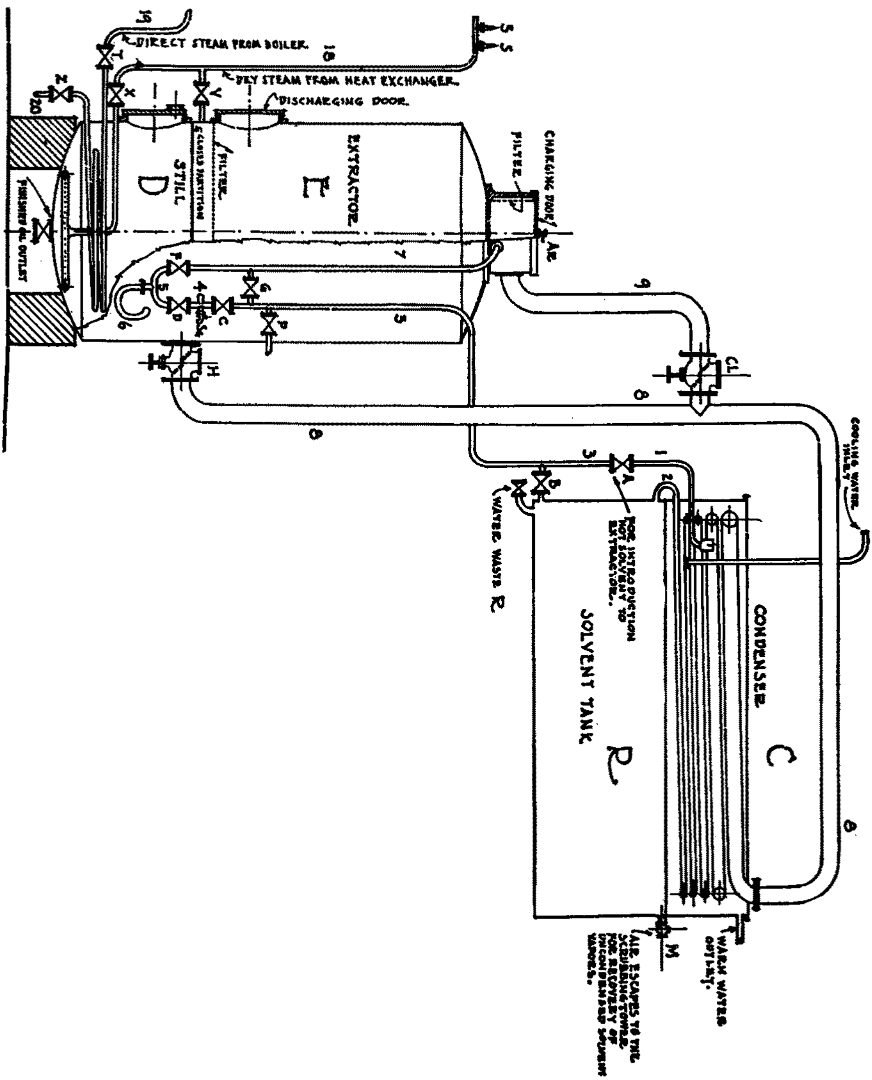
A large variety of materials may be advantageously extracted with solvents, such as oil-bearing seeds, copra, palm kernels, press-cakes, bones, etc. The treatment of a whole seed such as cottonseed, flaxseed, castor-bean, soya or a similar product will be discussed.

Crushing

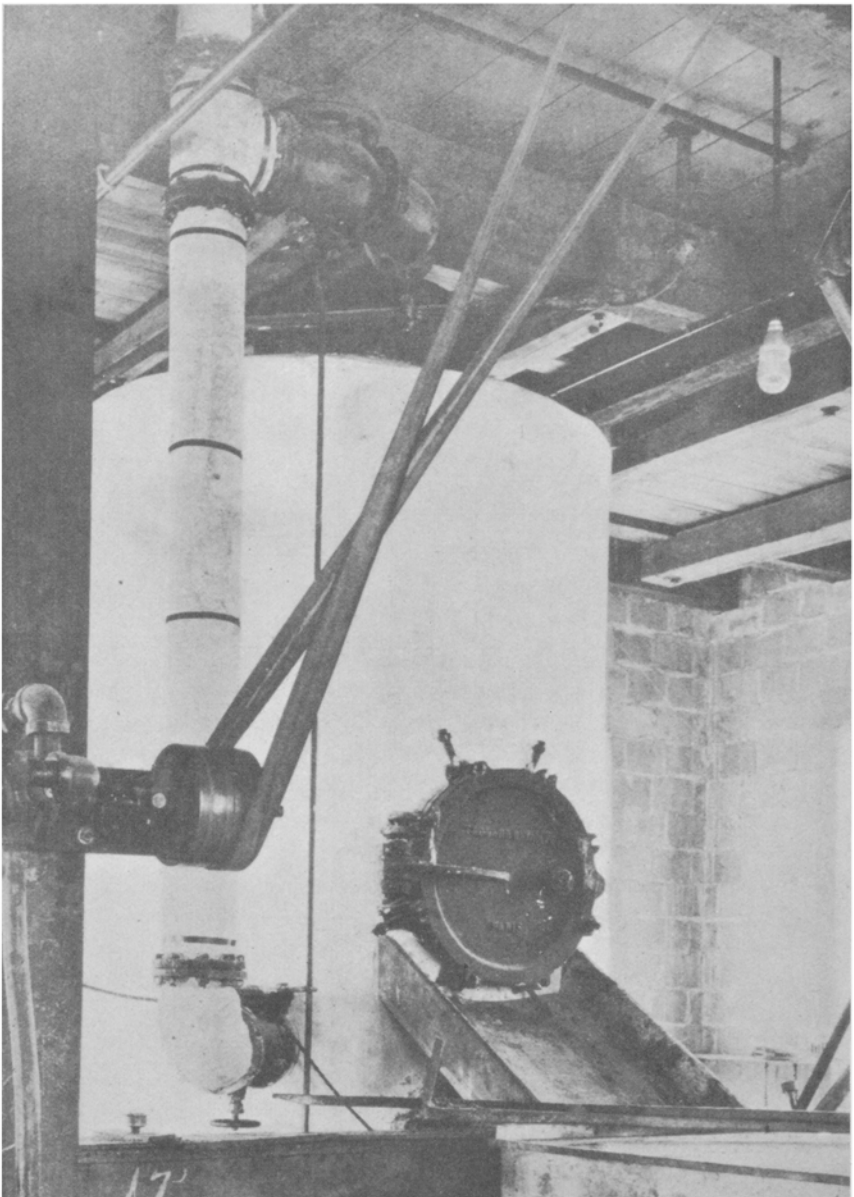
The first step—and a vitally important one—is the proper disintegration of the seed. This operation requires special treatment in connection with extraction. The crushers usually found in hydraulic press plants are not suitable for an extraction plant. The object of the operation is the breaking of the exterior of the seed, with the production of as little finely pulverized material as possible, since fines slow up extraction by clogging the filter cloths in the extractor. The most suitable crusher consists of a single pair of rolls each one operating at a different speed. This tears open the seed without mashing of pulverizing it. The ideal condition for cottonseed, for example, is to produce it in pieces 1/16 inch to 1/8 inch in size; for flaxseed, to break the seed into two or four pieces. The rolls should be capable of accurate regulation of spacing and the feed should be uniform. It is better to have an occasional whole seed pass, then to pulverize the product. The regulation of the operation of the rolls is accomplished by first permitting an evident quantity of whole seed to pass, and then gradually bringing the rolls nearer together until the point has been reached where whole seeds have ceased to appear in the crushed product.

Handling of Crushed Seed

The crushed seed should be handled as little as possible in order not to break it down further than was accomplished by the rolls. An ideal arrangement is the placing of the rolls on an upper floor so that the seed will discharge by gravity into a hopper for feeding the extractors. This is not always feasible in a layout, however, and as will be seen in Fig. 3, it is generally necessary to elevate the crushed material. Bucket-conveyors are satisfactory. For the transverse handling over the extractor a steel band conveyor is most suitable. Cloth belt conveyors become oil soaked and rancid; rubber is deteriorated by the oil. A screw conveyor, or a scrape conveyor are both to be avoided because of the increase in fine material that is caused by them.



Single Unit Extraction Plant



Flaxseed Extractor Showing Discharging Door from Which Extracted Material is Removed

Storing of Crushed Seed

After the material has been crushed, it should be stored for as short a time as possible because oxidation not only deteriorates the exposed oil, but the fermentation creates a tendency to foaming in the still used for distilling the solvent from the extracted oil. Consequently crushing should be done only as rapidly as the extrators can handle the material.

Charging the Extractor

The capacity of an extractor is dependent upon the number of charges per unit time; consequently any one of the several operations that can be speeded up is to the advantage of the owner. By having an entire charge ready and in a hopper above the extractor, as shown in Fig. 3, the material can be charged in rapid time through the chute. This has evident time saving advantages over charging from a conveyor. Another method is the use of a lorry hopper, running on tracks above each group of extractors. This avoids the necessity of the transverse conveyor and the handling of the material is at a minimum. The material rests upon the filter at the bottom of the extractor, which is filled to the neck of the charging casting.

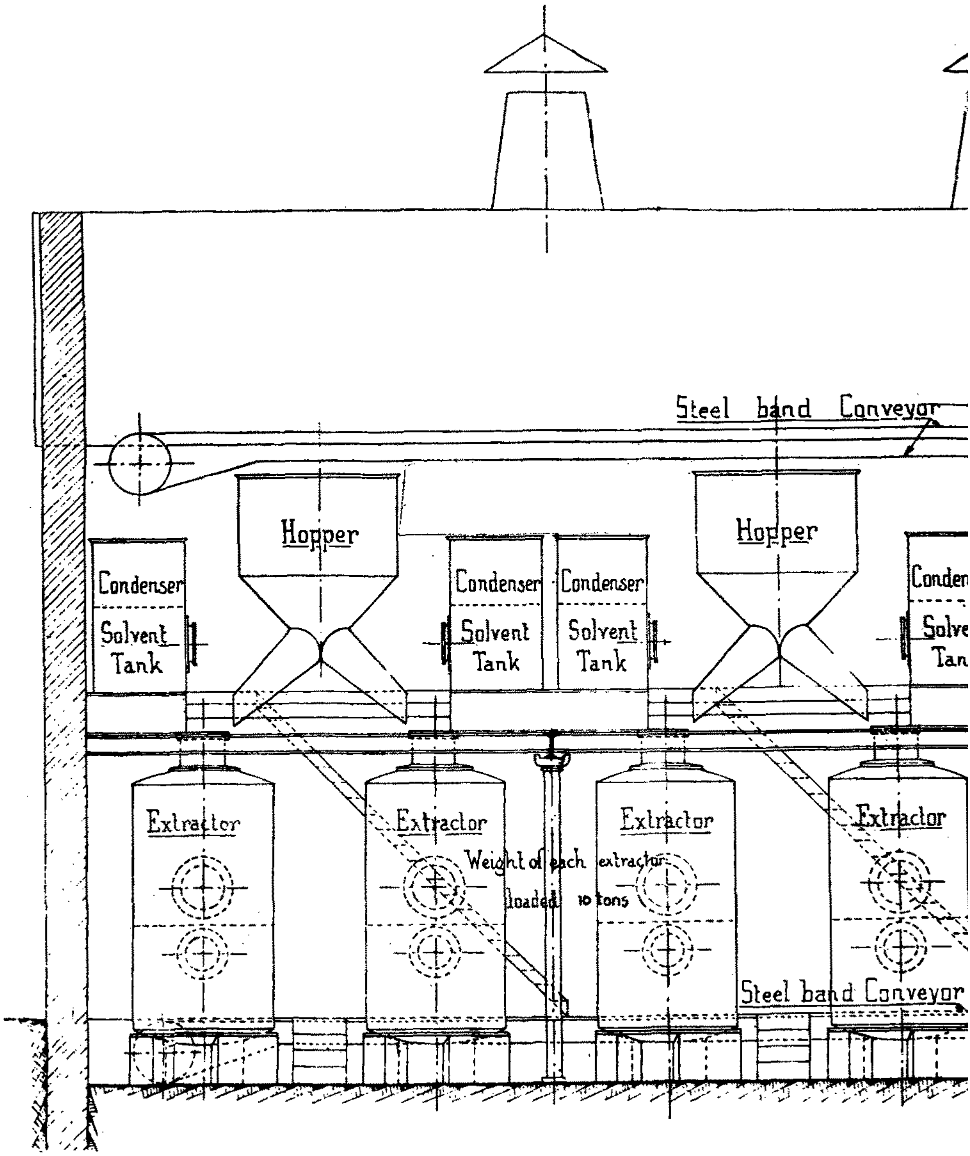
Introduction of the Solvent

When introducing the solvent, it is important to avoid the formation of channels, air-pockets, uneven welling of the material, and the tendency for it to pack against the filters. The apparatus shown in outline in Fig. 1, is so arranged as to avoid the above by having the solvent introduced at the bottom of the extractor, instead of at the top as is usually the case. The solvent rises through the material, thus decreasing the pressure of the seed against the bottom filter and forcing the air in the extractor to the condenser and solvent tank. Since this air has been in contact with solvent, it contains solvent vapor which would be lost when evacuating to the atmosphere.

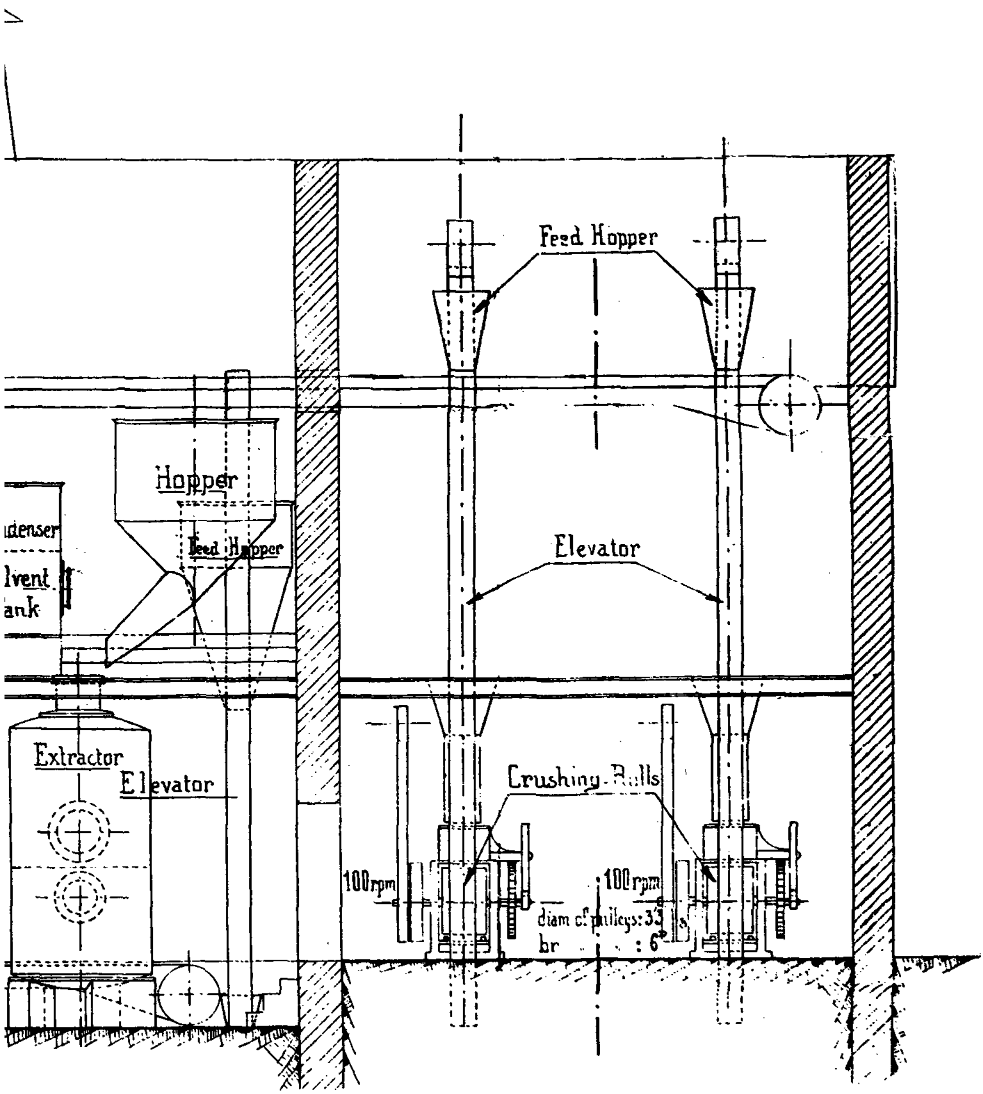
The Bataille installations recover this solvent by use of an oil scrubbing tower for each battery of extractors. This is connected to the individual tanks via the connection shown at the right of this tank, in Fig. 1. The oil generally employed for scrubbing is that produced in the plant. Intermittently it is run to one of the stills and the oil and the absorbed solvent returned to the system. This scrubbing tower also acts as the means of condensing vapors that may pass the condenser at any time during the subsequent operations, as it will be appreciated that a perfect condenser is commercially impossible without a refrigeration system.

Extraction and Distillation

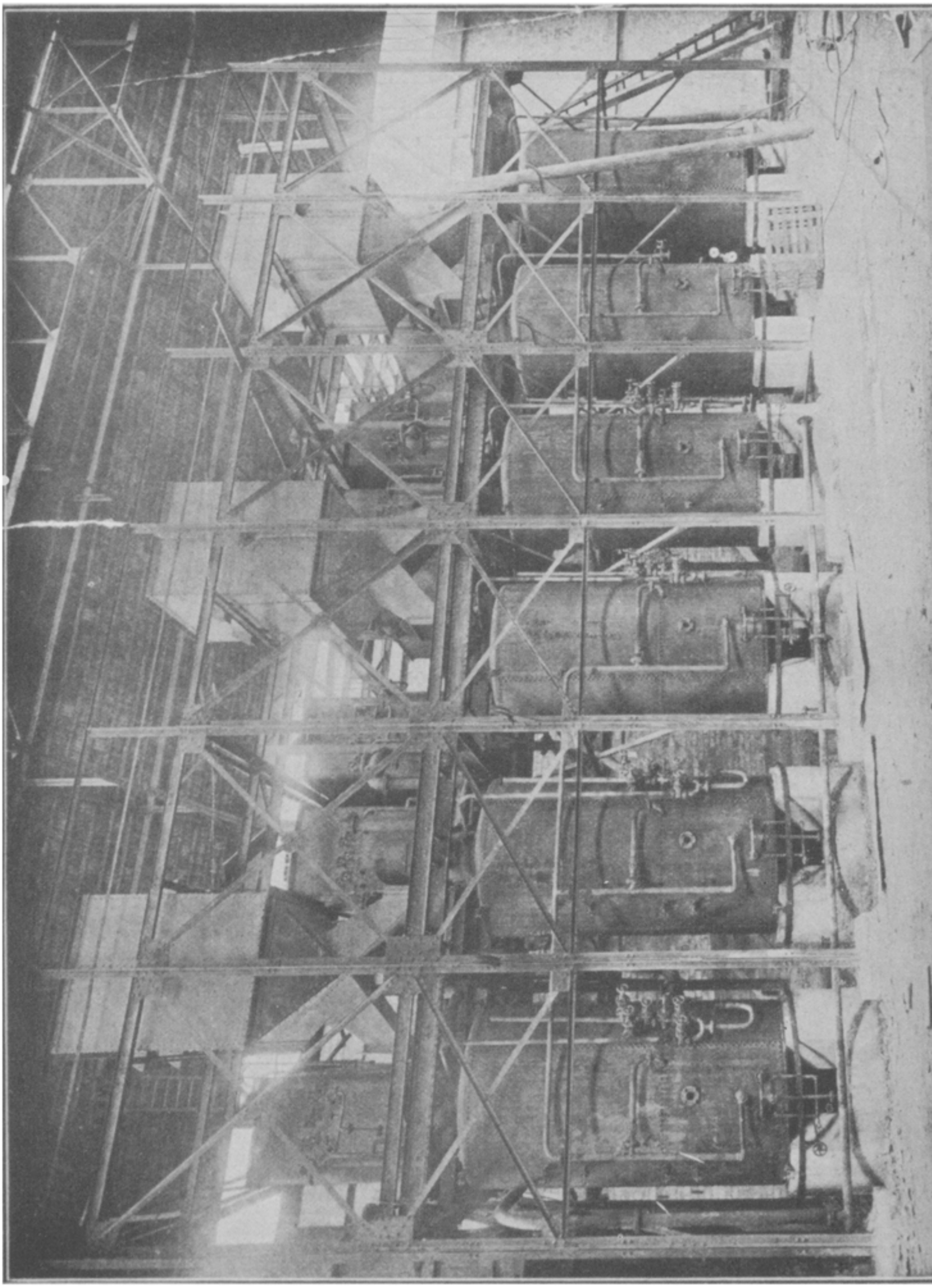
The extractor shown in Fig. 1 is capable of having the solvent flow proceed from the bottom upward, overflowing the solvent containing dis-



General Layout of Five-Extractor Extract



t Using Independent Operating Extractors



Modern Bataille Extractions Plant

solved oil through the drum shaped filter fitting around the interior of the charging casting and thence to the still by pipe 7; or the solvent current may be reversed. In both instances the extractor should be kept completely full of solvent. The upward flow is used in case a solvent such as trichlorethylene with a higher specific gravity than oil is used; the downward flow is indicated where a solvent is used, such as benzol or a special cut of gasoline which is lighter than the oil.

The oil bearing solvent overflows by gravity to the still and indirect steam vaporizes the solvent which passes by vapor pipe 8 to the condenser. At this point it is short-circuited and withdrawn through pipe 1. The solvent vapor at this point in the condenser, has been liquified but practically is at its boiling point and extraction is accelerated considerably thereby.

At the end of several hours extraction, about 1 per cent oil remains in the material. Although this can be reduced if desired it is not generally commercially worth while. However, the writer has visited a Bataille Extraction plant which produces an oil-free special diet for diabetics from wheat germs. Incidently this installation producing food for human consumption is interesting evidence of the fact that solvent free meal for cattle feed presents no difficulties of production, provided the proper solvent and design of extractor is employed.

Deodorization of Extracted Residue

In the early days of solvent extraction it was recognized that in order to properly deodorize the extracted residue of any trace of solvent, it was necessary to agitate the material during the period of steaming. The mechanical difficulties of agitating a mass of meal which is not floating in liquid are many, aside from the evident disadvantages of offering a chance of escape of solvent vapors at the stuffing box, as well as the power consumed. The early Bataille extractors adopted the agitator until the simple expedient of completing the extraction period with solvent vapors, instead of liquid, was invented. Referring to Fig. 1, it will be seen that when check valve C1 is lifted, the vapors from the still will be drawn directly into the extractor as the final drain is taking place. The temperature on the interior of the insulated extractor is a few degrees below the boiling point of the hot solvent used for extraction and the vapors replace the liquid so that when dry steam is blown through the material, the elimination of residual gaseous solvent is largely accomplished by displacement. The main reason for the existence of an agitator, therefore, no longer exists.

Deodorization of the Oil

To anyone familiar with oil refinery deodorizing practice, it will be readily appreciated that the steam distillation of an oil is capable of removing even remote traces of volatile esters and aldehydes, which cause the taste (or in reality odor) of the oil. The same principle is used in completing the extracted oil and it is probable that a slight deodorization of the oil takes place, even beyond the point of the removal of the low boiling solvent (which in all cases should have no products whatever boiling over 200° F.)

Discharging the Extractor

Mechanical discharge—either by rotating a horizontal extractor, or turning an agitator—takes about the same length of time as hand discharge. The comparitively dry material (containing about 14 per cent moisture) creates a considerable resistance to the agitator. The labor factor is not an item since the helper around the plant consumes from ten to fifteen minutes for extraction per extractor per shift to discharge by hand.

Drying

The discharged material has been subjected to direct steam during deodorization of the meal and its moisture content generally runs about 14 per cent, although its appearance is dusty dry. If the screw conveyor handling the discharged material is maintained hot by means of a steam jacket, this is sufficient to permit the evaporation of excess moisture over that usually required for the finished meal.

The general method of operation and the layout of a solvent extractor plant have been described above. In a subsequent paper the cost of operation and the effect and application of various solvents will be discussed in connection with different materials which may be advantageously extracted by solvents.

I. F. Laucks, Inc., analytical and consulting chemists, have removed their offices to 314 Maritime Building, Seattle.