recovery stills, the whole charge expands into a foamy mass of which, seemingly, a gallon will fill a large tank.

An endless number of methods and schemes have been tried, first and last, but apparently none had sufficient merit to survive the first attempts. Possibly many failed under market conditions which do not exist at the present time; or, what is more likely, at their beginning they promised so much that mere partial success gave nothing but discouragement.

Leaving the recovery method aside for the moment, are there any—and if so what are—the inherent values of sewage sludge? What type and condition of the sludge offers the greatest possibilities?

Grease and Nitrogen Content

Setting aside for the present the moisture content, the value of the sludge will be governed by its grease and nitrogen content. While all sludges contain small percentages of bone phosphate and potash, from a practical standpoint they may be neglected. Consider the following analyses (dry basis):—

	Ammonia	Grease
Baltimore sludge, acid process, fresh, ..	3.26%	27.23%
Boston sludge, acid process, fresh, ...	3.91%	29.30%
Chicago Sanitary District, activated sludge, fresh, ...	5.10%	14.70%
Pleasantville, N.Y., settling basins' sludge, one month in basins, ...	4.14%	27.40%
Syracuse settling basin's sludge, fresh, ..	4.02%	9.60%
Syracuse activated sludge, fresh, ...	5.06%	17.70%

All of those analyses are from samples of sludge produced from comparatively fresh sewage and are representative of sludge rapidly deposited and not allowed to rest in th tnks for any great length of time. For that reason little bacterial action had taken place and the ammonia and grease content are at their maximum for the different types of sludge. Compare with those, these analyses of samples of sludge from so-called septic tanks or sludge which has been exposed for a great length of time on drying beds:—

	Ammonia	Grease
Baltimore sludge (from tanks) on bed approximately 6 months, ...	2.34%	1.50%
Chicago, activated sludge, 9 months old, ...	4.40%	5.00%
Akron, O., sludge, 3 months in tank, 6 months on bed, ...	1.00%	6.00%

All other things being equal, the value of a sludge for by-product recovery purposes depends upon the shortest possible period of tanking and shortest elapsed time between tank and ultimate utilization. In other words, bacterial action and weather erosion must be restricted to a minimum. This is directly contrary to usual sewage practice and is one of the rocks on which the disposal proposition has stumbled.

Minimum Value Worth Recovering

Below a certain minimum of recoverable values, there is no use attempting recovery. This minimum seems to be, for low-grade ammoniates such as garbage tankage and sewage sludge, approximately 3% ammonia. Below this the expense of handling and freight cost put it out of all hope of competition with other and more concentrated materials. From an economic and business standpoint, any goods falling below this rating had better be forgotten and no time wasted on developing methods of handling.

Moisture content of sludge leaving tanks is the next most vital consideration. In order to come within economic range of any method of artificial drying of any material containing 3 to 3.3% ammonia and 10 to 15% grease on dry basis, moisture must not exceed 75 to 80%. All sludges as they come from tanks or basins are far above this, and activated sludge way beyond. Sludge from ordinary sedimentation basins can be drained and air-dried within several weeks to 77 to 80% moisture, and by centrifuging to about the same amount. It would appear, however, that the simplest and most inexpensive method is that of depositing sludge, after removal from tanks, on drainage beds exposed to atmospheric drying conditions. In any case, without the presence of water dumping facilities, the sludge must be partially dewatered before final disposition.

With sludge containing 75% moisture, the ultimate disposition with by-product recovery is not impossible, though difficult and presenting many curious conditions.

To accomplish the disposal with production of a marketable tankage and grease, the elimination of all of the moisture with subsequent extraction of the grease by volatile solvents, a system of drying, extraction and recovery in one operation is suggested. Such a combined and complete operation is carried out at the present time only by the Cobwell process.

This process, as is doubtless well known, is applied to the handling of municipal garbage, dead animals, slaughterhouse offal and other wet organic waste materials. At the request of several engineers and municipal officials, a number of small-scale and several large-scale experiments have been undertaken and carried out on sewage sludge, with results which seem to warrant some hope of solution of the problem.

Adaptation of Cobwell Process

It is unnecessary to go into any detail in description of a process with which most engineers are familiar. But some variations are required in applying it to handling of sewage sludge.

In this method of dehydration with simultaneous degreasing, the principle employed is that of desiccation in a hot bath of an immiscible solvent which shall serve not only as a dehydrating medium but shall also, during the period of drying, continually dissolve the grease contained in the material to be dried.

Such a solvent preferably employed in the handling of sewage sludge, is a high boiling petroleum naphtha, distilling within the range 360 to 420 degs. F., which corresponds to the first 60 to 70% over in the fractionation of "standard waterwhite kerosene." This material serves not only as the most economical heating medium, but owing to the high temperature maintained in the desiccating mass, serves to remove or dissolve the metallic soaps as well as the free grease.

Cold, or merely warm, solvents of a less oily nature have little solvent action on such soaps, but high boiling oils, particularly when carrying small quantities of grease, are able to dissolve them without difficulty. Upon cooling they are apt to be deposited as jelly-like masses or to cause the gelatinization of the whole solvent solution, and for that reason the solution must be treated, before entering recovery stills, in such a manner that the soaps are decomposed and a solution of clean fatty acids result. This treatment will be taken up in order.

Description of Apparatus

The following is a brief description of apparatus and the method of carrying out the operation:—

The principal apparatus consists essentially of a closed tank, circular in shape and of a diameter three times the height. Jackets are provided on the bottom and well up the sides, so that as much available heating surface is obtained as is possible. Through the bottom, oblong screened openings are provided for the withdrawal of solvent and grease, and for the pumping in of solvent during the cooking or desiccating operation.

Within the tank proper is a central shaft, provided with two sweeps set very close to the bottom in such a manner that they shall slide under the mass to be treated, imparting an undulatory motion, without cutting through the mass itself. For this reason very little power is required. The tanks are of shallow form in order that the amount of heating surface in proportion to the mass to be treated may be as great as possible. Greater height and capacity could only be obtained at the expense of operating time and greater consumption of power. The top of the tank is provided with charging manhole and outlet pipe to condenser for vapors.

After the tank is loaded with sludge, the charging manhole is securely closed by the swing cover, solvent is admitted through the bottom screens, sufficient to immerse totally the mass of sludge, and steam turned on jackets.