2

Pretreatment of Poultry Processing Wastes

Upgrading Poultry-Processing Facilities to Reduce Pollution

PA Technology Transfer Seminar Publication

EPA-625/3-73-001

PRETREATMENT OF POULTRY-PROCESSING WASTES

Upgrading Existing Poultry-Processing Facilities to Reduce Pollution

ENVIRONMENTAL PROTECTION AGENCY • Technology Transfer

July 1973

ACKNOWLEDGMENTS

This seminar publication contains materials prepared for the U.S. Environmental Protection Agency Technology Transfer Program and presented at industrial pollution-control seminars for the poultry-processing industry.

The basic publication was prepared by A. J. Steffen, Consulting Environmental Engineer, West Lafayette, Ind., with the assistance of Dan Lindenmeyer, FMC Corporation, Chicago, Ill.; M. E. Ginaven, Bauer Bros. Company (subsidiary of Combustion Engineering, Inc.), Springfield, Ohio; Robert Johnson, FMC Corporation, Atlanta, Ga.; and Charles Grimes, Rex Chainbelt, Inc., Waukesha, Wis.

PREFACE

Since most poultry plants are now using flowaway systems, the subject matter relates largely to this type of waste-handling system. The customary screens used in flowaway systems to remove offal and feathers are intended to improve the wastewater for reuse in the processing plant and for recovery of byproducts. They are therefore not considered as part of pretreatment for discharge to a municipal system, although it is recognized that effluent may often be improved by improvements in flowaway screening.

Pretreatment does not include treatment of sanitary wastes (normally discharged directly to the city sewer), storm water, cooling water, or condenser water.

Disposal of the recovered screenings, floatables, and settled solids is beyond the scope of this study, but concentration of the floatables and settled solids by screening to reduce liquid content is included.

CONTENTS

Part I

INTRODUCTION

WHY PRETREAT?

This paper is concerned with the treatment of poultry wastes *after* the customary screening in flowaway systems and prior to discharge to a municipal sewer. The term "pretreatment" will be used to cover all physical, chemical, or biological treatment provided for this purpose.

The majority of poultry plants discharge to municipal sewers. In a 1971 Department of Agriculture survey [8] of 386 poultry plants, almost two-thirds were connected to some type of public sewer system. The survey did not show how many had pretreatment. Whether pretreatment is required at a poultry plant depends most frequently upon municipal regulations regarding some of the ingredients in the poultry wastes. Ingredients such as feathers may be prohibited because they cannot be efficiently removed and disposed of in conventional municipal sewage treatment plants, whereas other ingredients, such as solids, may be subject to special charges to defray the expense of their removal and disposal in the municipal system.

Federal regulations covering grants-in-aid to municipalities touch on pretreatment of industrial wastes.

The Federal Water Pollution Control Act Amendments of 1972 require that before any grant approval to a municipality the Environmental Protection Agency must be assured that provisions are made to prevent the municipal system from receiving pollutants that would inhibit the operation of the municipal treatment works, or that would pass through the system untreated. In addition any municipality that will receive industrial wastes must have a system of surcharges such that the industrial discharger repays an equitable portion of the full cost of construction and operation of the system.

Thus, if the municipality receives a Federal grant, the poultry plant may be required to provide pretreatment *if* the waste would be detrimental to the system of municipal treatment. Note also that the cost of treating the poultry wastes must be recovered in "an equitable system of cost recovery." In some cases, municipal treatment requirements can be reduced by pretreatment at the poultry plant, which may produce overall savings to the poultry plant operator if a cost recovery charge is to be levied.

There are many other instances in which pretreatment may become an economic advantage. Suppose, for example, that the municipal plant is overloaded and a plant expansion is contemplated. A study shows that pretreatment at the poultry plant will eliminate the overload. The decision whether to pretreat or to go along with the municipal plant expansion program depends upon the relative annual cost of the two alternatives to the poultry plant operator.

As another example, suppose that excessive discharges of grease, feathers, or suspended matter are causing special problems in operating primary clarifiers and anaerobic sludge digestion at the municipal plant. The first step for correction of such problems is waste conservation at the poultry plant and attention to the flowaway system (a check for escape of solids in the flowaway screen and offal area). If these elements are all in order and good waste conservation is being practiced in the plant, pretreatment may be the next step.

As a further example, suppose that the poultry plant management is considering an increase in poultry production or some additional processing. The added sewage-treatment load resulting from such changes can be calculated, to compare the sewage service charges for municipal plant expansion made necessary by the added load with the cost of pretreatment to produce the same results.

WHEN TO PRETREAT?

Prohibitory and Restrictive Limits May Make Pretreatment Necessary

The discharge of some ingredients such as feathers, entrails, and the like into the municipal system may be completely *prohibited.* If the best in-plant conservation practices and careful operation of efficient flowaway equipment do not eliminate these materials to the municipality's satisfaction, some form of pretreatment will be necessary.

On the other hand, restrictive limits (that is, *limits of concentration* of biochemical oxygen demand (BOD), solids, and grease, for example, in milligrams per liter) may vary with the type of municipal treatment. For example, emulsified fats from poultry-cooking operations are amenable to activated sludge treatment, whereas they may be troublesome in a trickling-filter-type plant. A municipality with activated-sludge treatment could then recognize that emulsified fats would be paid for under BOD charges, with grease restrictions applying only to floatable grease.

Pretreatment May Reduce a Poultry Processor's Overall Waste-Treatment Cost When a Municipal Surcharge System Is Contemplated

Surcharge systems vary, and no one can predict whether pretreatment can be justified economically until costs are evaluated. A surcharge system should be based upon an evaluation, by the city's consulting engineer, of the cost of the elements of the municipal treatment plant necessary to accommodate the flow, remove the suspended matter, and treat the other ingredients of the industrial wastewater to the required levels, all on a unit basis (cost per pound of ingredient).

Many surcharge systems start with a flow base rate and apply multipliers for *concentrations* of any or all such ingredients as BOD, suspended solids, and grease. As an example, the flow base rate charged to all sewer users may be 50 percent of the water bill, including flow from private water supplies. Then, taking BOD as an example, assume that 250 mg/l has been established as a bottom base for *surcharges.* Then a multiplier might be applied for BOD between 250 and 500 mg/l, and a higher multiplier between 500 and 1,000 mg/l. Another set of multipliers might be applied for suspended solids, another for grease, others for other factors. These multipliers are then added together to establish a single multiplier to be applied to the flow base charge to arrive at the total bill.

In other surcharge systems charges for the pounds per month, above a base quantity, of BOD, suspended solids, and other ingredients are added to the flow charges based on gallons.

Summary

Except for compulsory action to remove materials prohibited from entering the city sewers, the *degree* of pretreatment is generally an economic decision. However, since plants differ and surcharges differ, no simple set of parameters can be established. Each case must be evaluated individually, not only to establish present practices but also to prepare for the future.

HOW TO PRETREAT?

Pretreatment can cover a broad range of wastewater processing elements, including screening, gravity separation of solids and floatables, pressurized air flotation, chemical treatment as an adjunct to gravity separation or flotation, and biological treatment such as aerated or unaerated lagoons or some other form of aerobic treatment.

Before any pretreatment is considered, an adequate survey should be made, including flow measurement, composite sampling, and chemical analysis, to determine the extent of the problem and the possibilities for pretreatment. Analyses may include BOD, suspended solids, suspended volatile solids, settleable solids, pH, temperature, and oils and grease. A permanent flow-measuring and composite-sampling arrangement is warranted if sampling is done regularly to determine municipal surcharges.

Most commonly, pretreatment will consist of separation of floatables and settleable solids. In some instances lime and alum, ferric chloride, or a polymer may be added to enhance separation. Paddle flocculation may follow alum and lime or ferric chloride additions to assist in coagulation of the suspended solids. Separation may be accomplished by gravity or by air flotation. Screening may precede the separation process and may also be used to concentrate the separated floatables and settled solids. These various systems will be discussed under separate headings.

Removal of floatables and suspended matter will also accomplish some reduction in BOD. Frequently this degree of treatment will satisfy municipal requirements. If additional BOD removal is required, a study of biological processes for pretreatment may be instituted, possibly in pilot scale. Several biological treatment systems have been successfully adapted to the treatment of poultry wastes. Lagoon treatment is discussed in the section on Direct Discharge to a Watercourse of the paper entitled "Waste Treatment." Other BOD removal systems may be suitable. The so-called "Dutch Ditch," which utilizes an aeration device in an oval-shaped shallow "race-track" ditch to recycle the flow, has been applied to meat-waste treatment and may be suited to poultry wastes as well. High-rate aeration, with clarification and sludge return (activated sludge), is available in many configurations.

A rotating biological contactor (fig. I-1) treats the effluent from an air flotation tank in a pretreatment system at a poultry plant in Illinois. In the contactor, wastewater flows through a tank in which a series of half-submerged disks, about 12 feet in diameter, rotate slowly on a horizontal shaft. As the shaft turns, a film of biological growth forms on the rotating surfaces. Rotation of the disks passes the biomass alternately through the wastewater where the biomass absorbs organic matter, then through the air where it obtains oxygen for biological metabolism. Excess biomass sloughs off and is separated in a clarification step. The plant in Illinois treats 130,000 gallons per day and is reported to remove 90 percent of the BOD in the wastewater leaving the flotation tank (influent at 2,000 mg/l, effluent at 200 mg/l).

COSTS

Costs of pretreatment depend on many factors, such as size of poultry plant, type of processing, space available for pretreatment, quality of in-house waste conservation, pumping requirements, municipal requirements regarding quality of effluent, local labor costs, construction costs, and Federal and State tax incentives for industrial waste treatment.

However, approximate costs of equipment are given wherever possible, as well as approximate costs of any chemicals required. Installation costs of prefabricated systems may be generally estimated at about 30 to 40 percent of equipment cost. Processors often prefer prefabricated units for convenience in installation.

Variations in loading due to changes in processing should not be overlooked in making rough approximations for sizing pretreatment. For example, cut-up and packaging can produce 15 percent greater BOD than processing to the eviscerating stage only, and fowl can increase grease content from the usual 1.0 to 1.5 pound per 1,000 birds to 1.5 to 2.0 pounds.

In spite of the wide divergence of costs, some examples of costs of plants, as built, may be useful. In one recent instance in Arkansas, in a plant processing 5,000 broilers an hour, with partial cut-up and packaging and some deep fat frying, a 20 X 20 mesh vibrating secondary screen (4 feet X 10 feet) cost $20,000 installed, including a 200-gpm pump. Installation of dual pumps, which is advisable, would probably add from $1,000 to $2,000 to this figure. Another plant in Arkansas, killing and eviscerating birds and preparing frozen dinners, installed pretreatment in 1969, treating 1,250,000 gallons of wastewater daily. Secondary screening cost $19,500, a vacuator for grease removal (see part III) cost $45,000, and buildings, flumes, piping, and controls cost $259,000, for a total of $323,500.

A pretreatment plant under design for a Georgia processor will cost $80,000 to $100,000, including pumping and pretreatment to produce an effluent of 300 mg/l BOD and suspended solids and 100 mg/l fats and grease. The plant processes 6,000 birds per hour, including eviscerating, cut-up, and packaging.

A screen plus a gravity grease separator treating 330,000 gallons per day from a killing and eviscerating plant in Canada cost $85,500 installed, excluding the cost of the building.

A pretreatment facility in South Carolina which handles offal and blood in addition to 2,800,000 gallons of daily flow for a plant killing and eviscerating birds and preparing frozen dinners cost $278,000 for screening and a vacuator in 1965. The building cost an additional $125,000.

The plant in Illinois, described in an earlier paragraph, with air flotation and revolving-disk contactor system, cost $80,000. The contactor alone cost $22,000.

SUMMARY

The following outline suggests procedures for developing a decision matrix for pretreatment:

- Select a project manager. He may be a company engineer or a consulting engineer, depending upon the extent of the study and the capability of company personnel to produce the necessary information.

- Measure flow and collect and analyze composite samples over a period of days sufficient to develop maximum as well as average data.

- Make an in-plant waste conservation survey. The annual cost for each possible change should include:

—Amortized cost of improvements, installed

—Power costs (heating, cooling, pumping)

—Chemical costs

—Labor cost (maintenance and operation)

- Make a study of possible pretreatment systems, with annual costs developed from the in-plant waste conservation survey.

- Determine the annual cost of municipal surcharges and compare with costs already determined.

- Select the elements of the conservation survey and possible pretreatment systems that are economically justified.

- Design necessary improvements considering:

—Portability of system

—Flexibility for alteration and expansion

—Operating skills required

—Cost of disposal of residual solids and grease

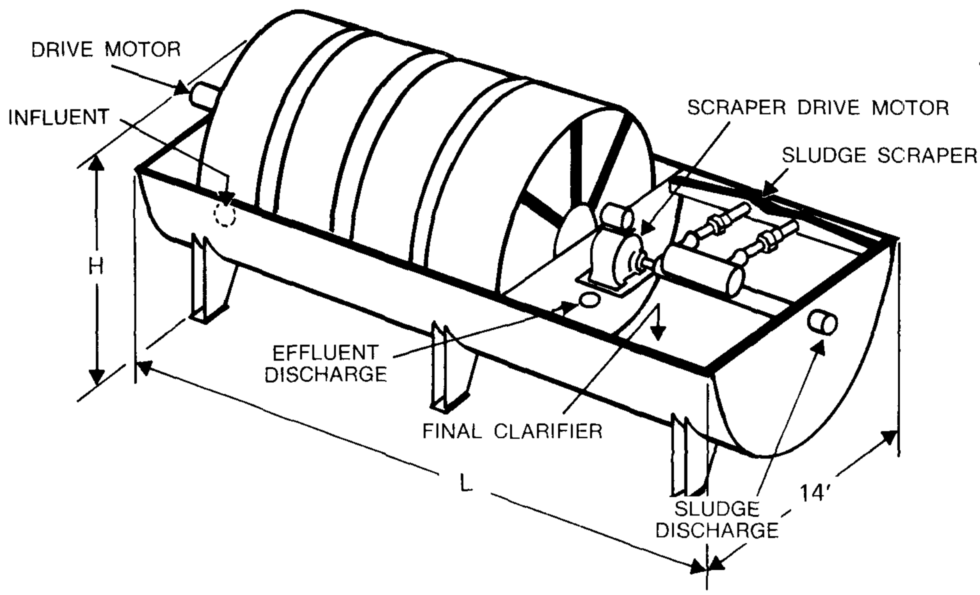


Figure I-1. Rotating disk contactor.

Part II

SCREENING

INTRODUCTION

In pretreatment, secondary screens may serve for final polishing with no further pretreatment after flowaway, or they may precede air flotation systems and gravity separation basins to reduce the bulk of solids that would otherwise have to be removed in the subsequent units.

Screens vary widely both in mechanical action and in mesh size, which ranges from 0.5-inch openings in stationary screens to 200 mesh in high-speed circular vibratory polishing screens. In some cases the efficiency of screening in the flowaway systems may be sufficient to circumvent secondary screening; in others, secondary or polishing screening may be warranted. Floor drains not connected to the flowaway systems are usually then discharged to this polishing screen. With no secondary screening, the floor drains in the offal room and those adjacent to the flowaway screens and offal conveyors should be pumped back to the flowaway screen influent. These floor drains are frequently the source of serious problems when difficulties arise in the flowaway screen systems or conveyors.

In some plants "followup" stationary screens, consisting of two, three, or four units placed vertically in the effluent sewer before discharge to the municipal sewer, have successfully prevented escape of feathers and solids from the drains in the flowaway screen room and other drains on the premises. These stationary "channel" screens are framed and are usually constructed of mesh or perforated stainless steel with ¼- to ½-inch openings. The series arrangement permits removal of a single screen for cleaning and improves efficiency.

VIBRATING SCREENS

The vibrating screen is a structure with means for producing a rapid motion with one or more perforated or meshed surfaces for separating material according to size. The effectiveness of a vibrating screen depends on a rapid motion. Vibrating screens normally operate at speeds of 1,000 to 2,000 rpm in a motion of 1/32 to 1/8 inch.

A successfully operating screen of any type must accomplish a combination of the following functions:

- Conveyance of material retained on the screen surface to uncover the opening, so that the cloth can pass the undersize material or liquid.

- Agitation of the bed of material on the screen surface. Agitation and stratification are required to open the bed so that the fine particles or liquids can work their way down through the large particles and pass the opening.

- Dislodgment of particles that stick or wedge in the opening. Particles of nearly the same dimension as the opening will clog. Motion of the screen must dislodge the particles.

- Distribution of the material in order to take full advantage of the area of the screen. The material must be distributed over the surface to insure efficient screening. The motion of the deck should distribute the material over the deck evenly.

- Retention before discharge. For high efficiency, sizing, or removing water from the solids, it is desirable to retain the oversize as long as possible. The material must be moved faster at the feed end to obtain quick distribution and a shallow bed where the volume is the greatest. At the discharge end where the volume is least, the rate of travel should be slowed to allow the remaining fines or liquids to be removed.

Following are some of the advantages of the vibrating screen over the rotary in handling poultry plant waste:

- The vibrating screen requires less floor space and less horsepower for operation.

- Spray water is usually not needed to wash particles from the screen cloth.

- The screen cloth required to resurface a vibrating screen is less than one-third the amount needed for a revolving screen and much easier to install.

- The initial cost of a vibrating screen is lower in most cases.

- The vibrating screen produces drier tailings owing to its motion.

The vibrating screen is driven by a shaft turning in a pair of bearings. The shaft carries unbalanced weights, either machined into or keyed to the shaft. This assembly is usually driven by a V-belt drive.

When the unbalanced weights are rotated the screen follows the weights through a path. When a vibrator is placed on the top of the box, a slight rocking action will take place, resulting in elliptical motion with the ellipse leaning toward the vibrator. This motion tends to move the material away from the feed end and retard it at the discharge end. The screen box is mounted on springs to keep vibration from being transmitted to the supports.

On most vibrating screens the cloth is pulled tightly across longitudinal steel members equipped with rubber caps. The cloth may be changed easily by loosening the tension bolts and sliding it out at either end.

Of prime importance in the selection of a proper vibrating screen is the application of the proper cloth. The capacities on liquid vibrating screens are based on the percent open area of the cloth. With this in mind, cloth should be selected with the proper combination of strength of wire and percent of open area. If the waste solids to be handled are heavy and abrasive, wire of a greater thickness and diameter should be used to insure long life. However, if the material is light or sticky in nature the durability of the screening surface may be the smallest consideration. In such a case, a light wire may be necessary to provide an increased percent of open area and more free screen-cloth conditions.

Screen cloth is woven in a variety of materials, such as black steel, spring steel, all types of stainless steel, Monel, and brass wire. Normally, on liquid waste applications, a type No. 304 stainless steel wire is used. However, when conditions require other types of metal, special wire cloths can be supplied.

In our discussion of various installations the term "mesh" will be used frequently to designate the opening. Where mesh is referred to as a number, the reference is to the number of openings to the linear inch. The mesh is counted by starting from the center of one wire and counting the number of openings to a 1-inch distance. If the count does not work out to an even number, the fractional part of the opening should be specified.

The actual opening between the wires is known as "space." Thus, ¼-inch space, .135 wire implies that the wires are ¼ inch apart and the diameter of the wire is 0.135 inch. We have standardized on a 20-mesh screen for offal, a 36 X 40-mesh screen cloth for feathers, and a 36 X 40-mesh for pretreatment. On most applications a double-crimped square-weave cloth is used. Double-crimped wire is woven in such a manner as to arch the shoot wire over the warp and then the warp wire over the shoot. Each wire then forms a support for the other, keeping both wires tight and rigid, thus eliminating shifting or slipping.

We will now see how a liquid dewatering vibrating screen can be used effectively in the pretreatment of poultry plant waste for discharge to a municipal system.

There are many vibrating screens in service in poultry plants throughout the United States—too many to list. They are installed as feather screens, as offal screens, and as pretreatment screens for discharge to municipal systems.

The following cost data are necessarily limited to screens manufactured by FMC Corporation.

The liquid vibrating screen is manufactured in sizes that vary from 2 feet 0 inches wide X 4 feet 0 inches long to 4 feet 0 inches wide X 10 feet 0 inches long. The most common unit supplied is an NRM-148 liquid dewatering screen (fig. II-1). This screen is 4 feet 0 inches wide X 8 feet 0 inches long, and as a pretreatment screen is equipped with a 36-mesh X 40-mesh 304 stainless steel screen cloth. The unit will handle approximately 600 gpm of wastewater. An NRM open screen complete with stainless steel screen cloth and drive will cost slightly less than $2,000. An NRM-148 liquid dewatering screen complete with screen cloth, drive, and feed flume and tank will cost slightly more than $3,000.

The NRM-148 screen, as a feather screen, will handle feathers from about 8,000 birds per hour. As an offal screen, it will handle the viscera from about 10,000 birds per hour.

The influent to the pretreatment screen has had most of the feathers and viscera removed. The screen's primary function is to remove most of the remaining solids from the plant wastewater before it goes to the sewage-treatment plant. The ideal way to feed a vibrating screen is directly by gravity from the flowaway system. The velocity of the water must be fed over the screen to reduce screen blinding. The screen is installed at a 10° downslope; as the pretreatment screen is subjected to wastewater with a high fat content, the less pumping that is done, the longer the screen cloth will operate without blinding. Pumping breaks down fat in the water, and the smaller particles cause blinding. Emulsified fats from cooking can also have the same effect. In some plants where a high percentage of the fats is emulsified, either the screen cloths must be sprayed intermittently with hot water or steam to remove the fat or an automatic spray system may be installed.

Good efficiency in feather removal is reported. In fact, a plant engineer at a poultry plant in Athens, Ga., states that a 4 X 8 vibrating screen operating as a pretreatment screen showed only one feather in the effluent in a 24-hour test.

The normal maintenance on a liquid dewatering screen consists of greasing the bearings at regular intervals and maintaining the proper spring tension on the screen cloth. If the screen cloth breaks and the break is parallel to the longitudinal members of the screen deck, the screen is too loose.

The operating cost of an NRM-148 liquid dewatering screen is the cost of the current required to operate a 2-hp motor.

STATIC SCREENS

During the past several years, a substantial number of so-called static screens have been installed in many process industries to recover suspended matter from plant effluents or liquid flows within a plant. Highly successful screening operations have been achieved in the meat packing, tanning, canning, textile, and paper and board products industries, as well as in domestic sewage-treatment operations. Interesting new developments are underway, such as the treatment of wastes from animal-producing farms and poultry-processing plants.

In most instances, the installed equipment represents new functions or concepts in recovery and generally involves recycling or some other use of the recovered solids. In many cases, stationary screens are installed as replacements for screens that require moving parts to make a suitable separation of solids from a process stream.

Basic Design Concepts

The primary function of a static screen is to remove "free" or transporting fluids. This can be accomplished in several ways; in most older concepts, only gravity drainage is involved. A concavely curved screen design using high-velocity pressure feeding developed and patented in the 1950's for mineral classification has been adapted to other uses in the process industries. This design employs bar interference to the slurry which knives off thin layers of the flow over the curved surface.

Beginning in 1969, U.S. and foreign patents were allowed on a three-slope static screen made of specially coined curved wires. This concept used the Coanda or wall attachment phenomenon to withdraw the fluid from the underlayer of a slurry stratified by controlled velocity over the screen. This method has been found to be highly effective in handling slurries containing fatty or sticky fibrous suspended matter.

Since the field tests to be reported were conducted on the later design of stationary screen, details of this unit are presented here. The device is known commercially as a Hydrasieve. A typical installation of a single screen operating on industrial wastewater is illustrated in figure II-2.

Method of Operation

The slurry to be screened or thickened is pumped or may flow by gravity into the headbox of the machine. As shown in figure II-3(a), the incoming fluid overflows the weir above the screen area and is accelerated in velocity and thinned in depth as it approaches the screen. A lightweight hinged baffle is incorporated into the assembly in such a position that it reduces turbulence in the flow. Turbulence is reduced by the shape of the foil, which causes the fluid to respond to Bernoulli's theorem through the wedge-shaped entrance. The increasing velocity of fluid draws the baffle toward the surface of the screen.

Suspended solids tend to stratify in the thin stream, and fibrous materials align themselves lengthwise with the direction of flow. Figure II-3(b) shows a segmental section of the screen wires and the slurry as it contacts the upper end of the Hydrasieve screen. Note that the wall attachment of the fluid to the metal bars or wires draws or bends an underportion of the flow through the openings. Part of the underflow also moves along the arcuate surfaces of the wires and is primarily concentrated at the apex of the downward curve. Here it falls by gravity from the screen back or flows in streams attached to the underside of the wire assembly in a central path between the supports. The screen pattern permits a maximum of fluid extraction based on the limit of flow rate and screen area. Figure II-3(c) illustrates the screen design, which is registered under the trademark Mar-Vel′.

On the first (top) slope of the screen most of the fluid is extracted from the bottom of the stream traveling at 25° from the vertical. When the angle of the screen changes to 35° some additional fluid is withdrawn, and usually the massing solids begin to roll on the surface, owing to the residual kinetic energy. This action compacts the solids very slightly. On the final slope of the screen, the solids tend to hesitate for simple drainage action but are always moved off the flat surface by displacement with oncoming material. The effluent is aerated as it passes through the screen in ultrathin ribbons completely exposed to a natural or controlled atmosphere.

Unique Features

The arrangement of transverse wires with unique singular flow curves provides a relatively non-clogging surface for dewatering or screening. The screens are precisely made of No. 316 stainless steel and are extremely rugged. Harder, wear-resistant stainless alloys may also be used for special purposes.

Openings of 0.010 to 0.060 inch meet normal screening needs. The essential features of the Hydrasieve are covered in U.S. Letters Patents No. 3,452,876 and No. 3,751,555. Other U.S. patents are pending. Patents are also issued and pending in foreign countries.

Advantages

The Hydrasieve has a number of advantages over vibrating and rotary screens, including:

- Initial cost is low.
- It is compact and inexpensive to install.
- There are no motor, no wires, no moving parts, no noise, no safety problems.
- It requires little, if any, attention.
- Construction is stainless steel. Fiberglass frame is optional.
- There are no screens to puncture, warp, or blind.
- Wide variation in flow rate or loading does not seriously affect performance.
- Uniform terminal solids moisture can be maintained.
- Units can be readily combined with secondary and tertiary biological treatment systems.
- Assemblies of units are readily constructed to meet high-capacity flow needs.

In-Plant Testing Results

A series of tests were conducted with small Hydrasieve screens in an Ohio poultry-processing plant in the autumn of 1972. A simplified drawing of the wastewater flow is shown in figure II-4.

It was found that some suspended solids could be removed immediately following screening for viscera (rotary 20-mesh screen), as well as after a treatment of the water with lime and alum. However, the continuous operation of the unit required steam sprays to prevent an accumulation of fatty film on the V-bars, which interfered with the establishment of a good fluid wall attachment on the screen.

No problems were encountered when the effluent was screened from the flotation system. The principal testing was done with a Hydrasieve located on the flow to the sewer as indicated in figure II-4 at position 4. A secondary advantage for using a screen in this location is that it rescreens all effluent water prior to its discharge to the city sewage system.

An adequate evaluation period on full flow volume has not been achieved, but test results show a worthwhile removal of fine suspended solids, along with a small drop in BOD levels. Some improvement in BOD is credited to the aeration provided by the Hydrasieve. Some minor improvements in color have been observed; the pH is also raised slightly.

The brief specifications in table II-1 are suitable for preliminary planning of an installation of effluent screen.

Summary

While the screening device described is now widely accepted for solids removal from effluents in many processing plants, it is not yet well established in the poultry industry, owing primarily to the manufacturer's brief experience with this industry's operations and problems. However, the exploratory work done within the past several months has indicated that improvements in effluent quality can be made economically.

Table II-1.—*Typical design information for chicken processing plant effluent based on use of 0.020-inch slot opening*

Hydrasieve	Overall dimensions, feet			Weight, pounds	Capacity, gpm	Price for estimating, dollars
	Width	Depth	Height			
No. 552-18″	2	3.5	5	350	25	2,600
No. 552-36″	3.5	4	5	550	50	3,200
No. 552-48″	4.5	5	7	650	125	4,000
No. 552-60″	5.5	5	7	800	175	5,000
No. 552-72″	6.5	5	7	1,000	225	6,000
No. 552-72-2	7	9.5	7.3	1,800	450	10,000
No. 552-72-4	14	9.5	7.3	3,600	900	20,000
No. 552-72-6	21	9.5	7.3	5,400	1,350	30,000
No. 552-72-8	28	9.5	7.3	7,200	1,800	40,000
No. 552-72-10	35	9.5	7.3	9,000	2,250	50,000

OTHER SCREENING DEVICES

Rotary Screen (Revolving, Trommel, Scrubber, or Barrel Screens)

Rotary and vibrating screens are the most popular types in poultry wastewater processing.

One type of barrel or rotary screen (see fig. II-6(a)), driven by external rollers, receives the wastewater at one open end and discharges the solids at the other open end. The liquid passes outward through the screen, usually stainless steel screen cloth or perforated metal, to a receiving box and effluent sewer mounted below the screen. The screen is usually sprayed continuously by means of a line of external spray nozzles. The screen is usually inclined toward the solids exit end. This type is popular as an offal screen, but has not been used to any great extent in secondary screening.

The other most common type of rotary screen, used to some extent in secondary screening, is driven by an external pinion gear. The influent is discharged into the interior of the screen below center, and solids are removed in a trough and screw conveyor mounted lengthwise at the center line of the barrel (see fig. II-6(b) and fig. II-6(c)). The liquid exits outward through the screen into a box in which the screen is partially submerged. Perforated lift paddles mounted lengthwise on the inside surface of the screen assist in lifting the solids to the conveyor trough. This type of screen is also generally sprayed externally to reduce blinding. Four of these screens (5 feet in diameter by 12 feet long with 10 X 10 mesh cloth) were installed at the municipal sewage-treatment plant in Gainesville, Ga., in 1964 to polish the raw wastewater. Operating at 4 rpm, each treats 2 million gallons per day. In 1964 there were seven poultry-processing plants in Gainesville. The central system solved maintenance and operating problems at the municipal plant resulting from residual feathers and offal not captured by offal and feather screens at the processing plants.

Other Mechanical Screens

Several other types of mechanical screens have had limited application in this field.

One is a rotating disk that is partially submerged in the wastewater flow. As it rotates, particles partially adhere and are scalped off above the flow. The screen disk is placed vertically or at a slight angle.

Another mechanical type is a circular spring-mounted horizontal screen, driven by a motor located under the screen and equipped with variable eccentric weights. As the motor rotates, the eccentric weights impart multiplaned vibrations to the spring-mounted screen. These units are usually centrally fed at the top, the liquid discharging through the screen to a pan above the motor and sludge discharging from a port at the periphery (see fig. II-7). Small units (18 inches diameter) are available on loan for testing.

There are many other ingenious mechanical screens, but they have not been tested on poultry wastewaters. Some, such as a vertical spinning drum, have successfully screened red meat waste solids. Under the impetus of need to improve effluents, testing such devices on poultry waste may be accelerated.

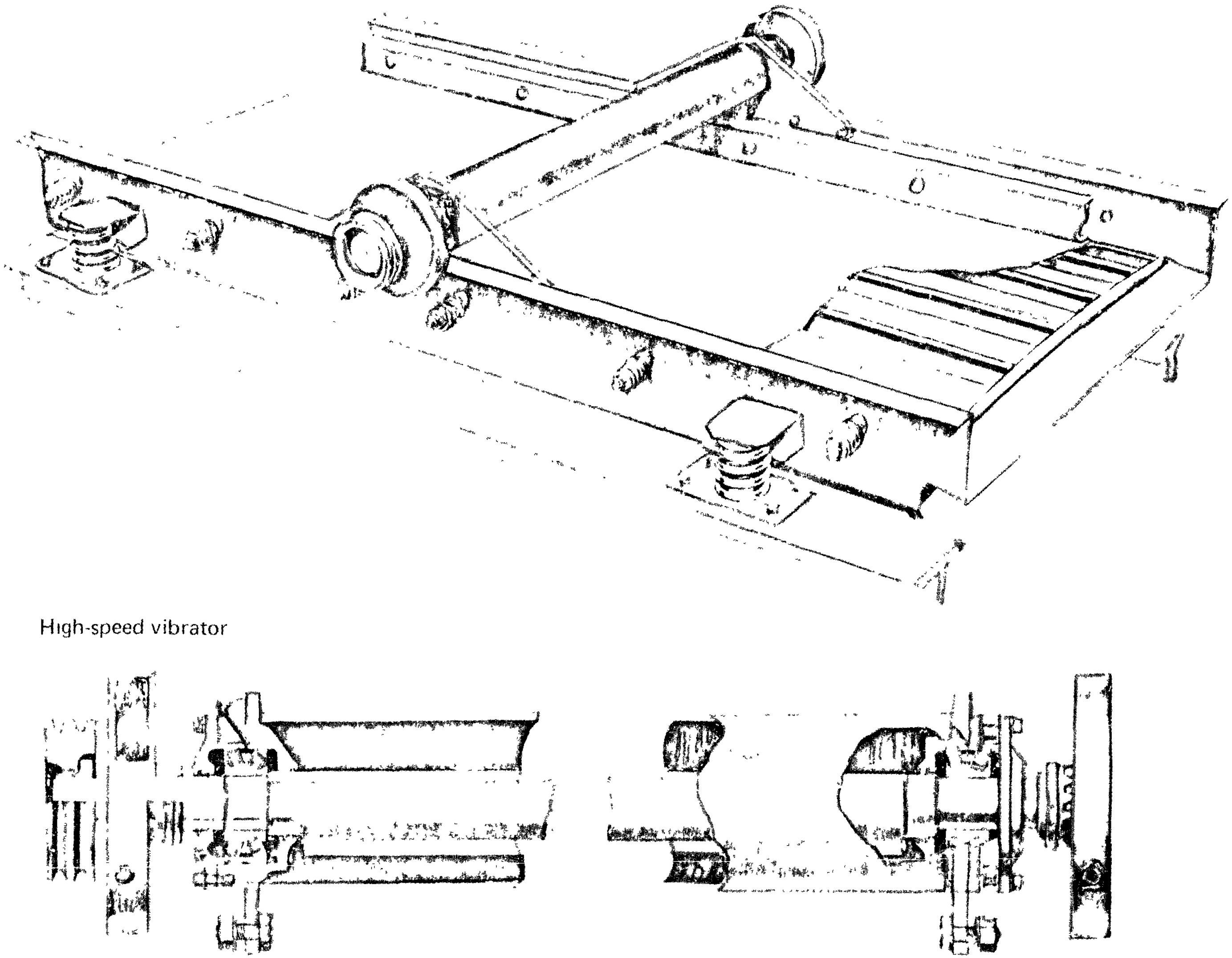


Figure II-1. NRM-148 liquid dewatering screen.

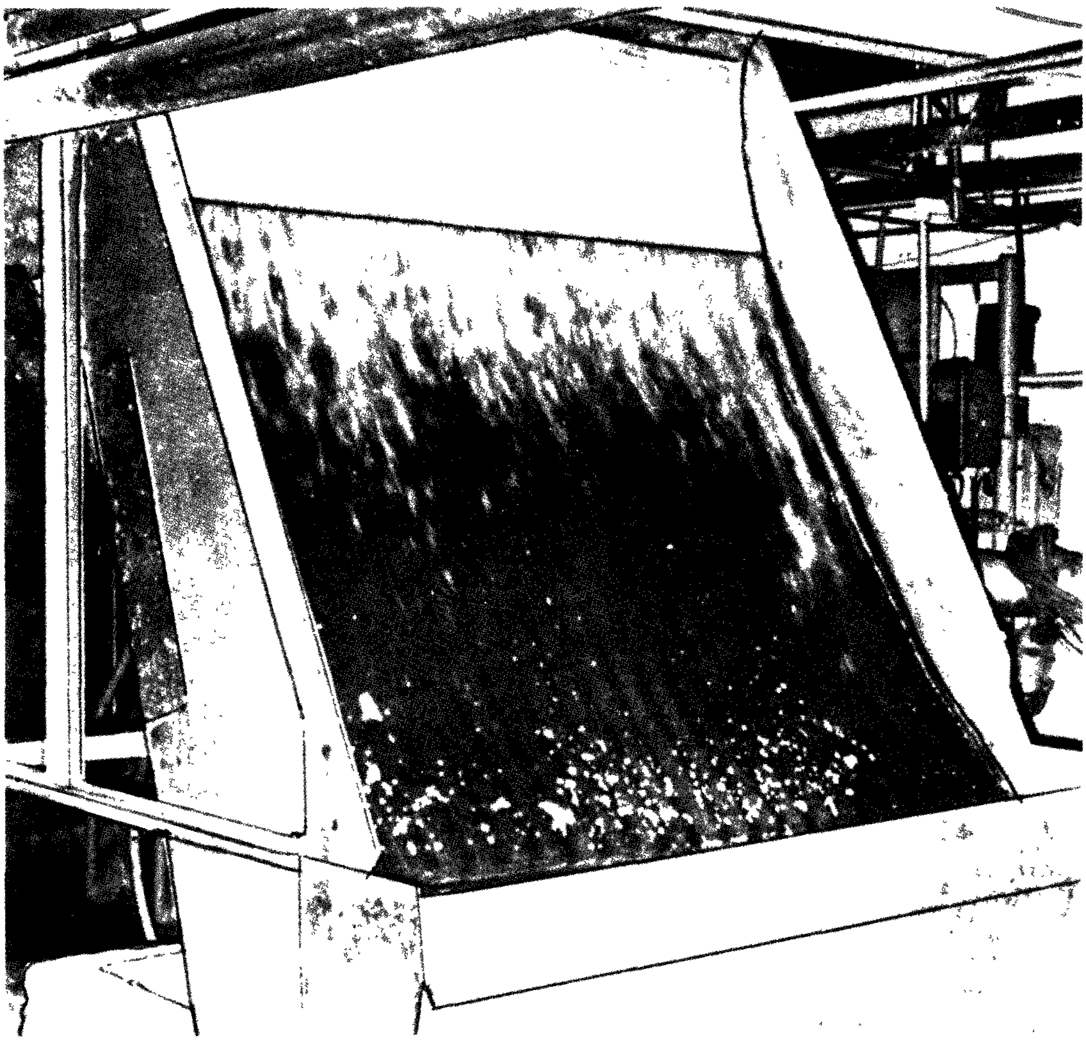


Figure II-2. Single Hydrasieve screen operating on industrial wastewater.

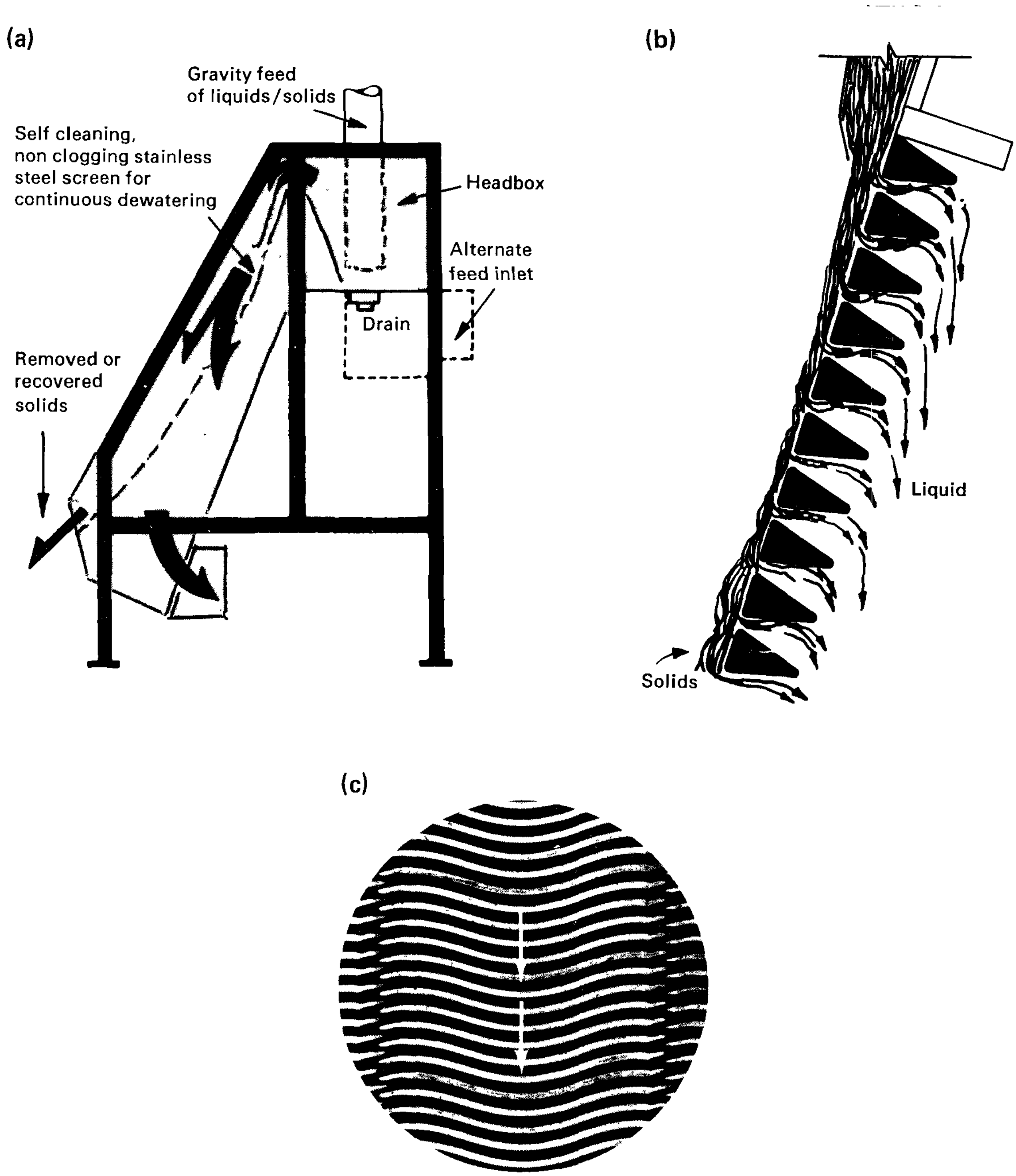


Figure II-3. (a) Diagram showing path of slurry screened by Hydrasieve. (b) Segmented section of screen wires with slurry contacting upper end of Hydrasieve screen. (c) Screen design of Marvel' Hydrasieve.

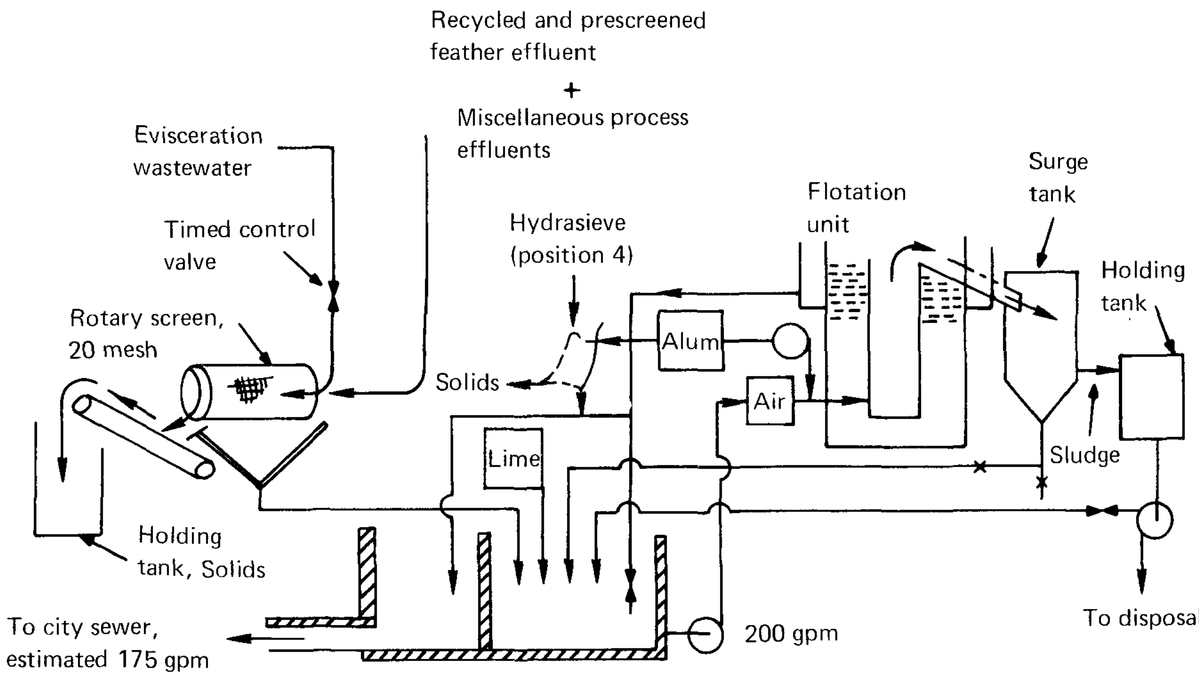


Figure II-4. Wastewater flow system in chicken-turkey processing plant using small Hydrasieve screens.

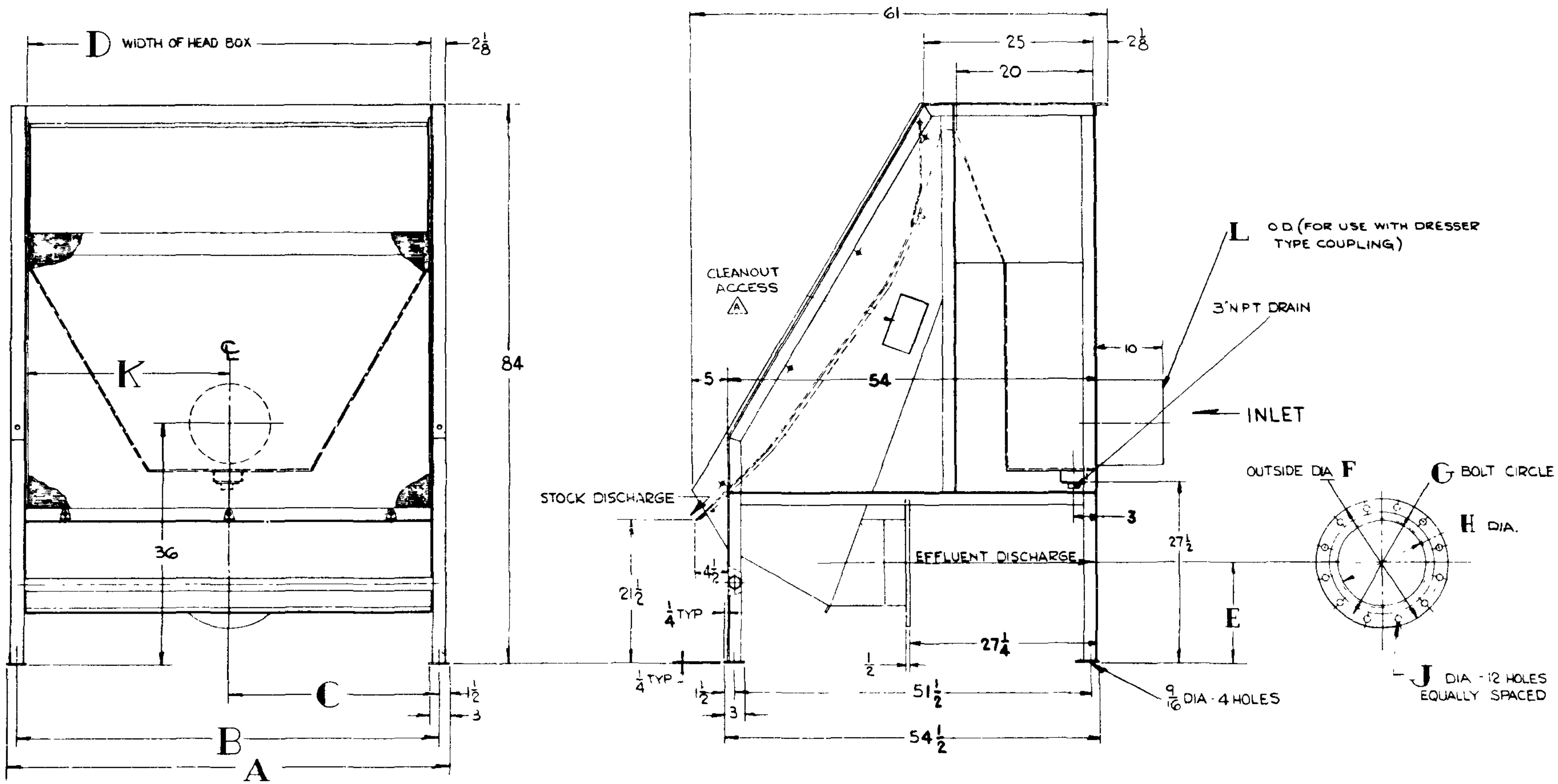


Figure II-5. Diagram for model 552-36 Hydrasieve. (Courtesy of the Bauer Bros. Co.).

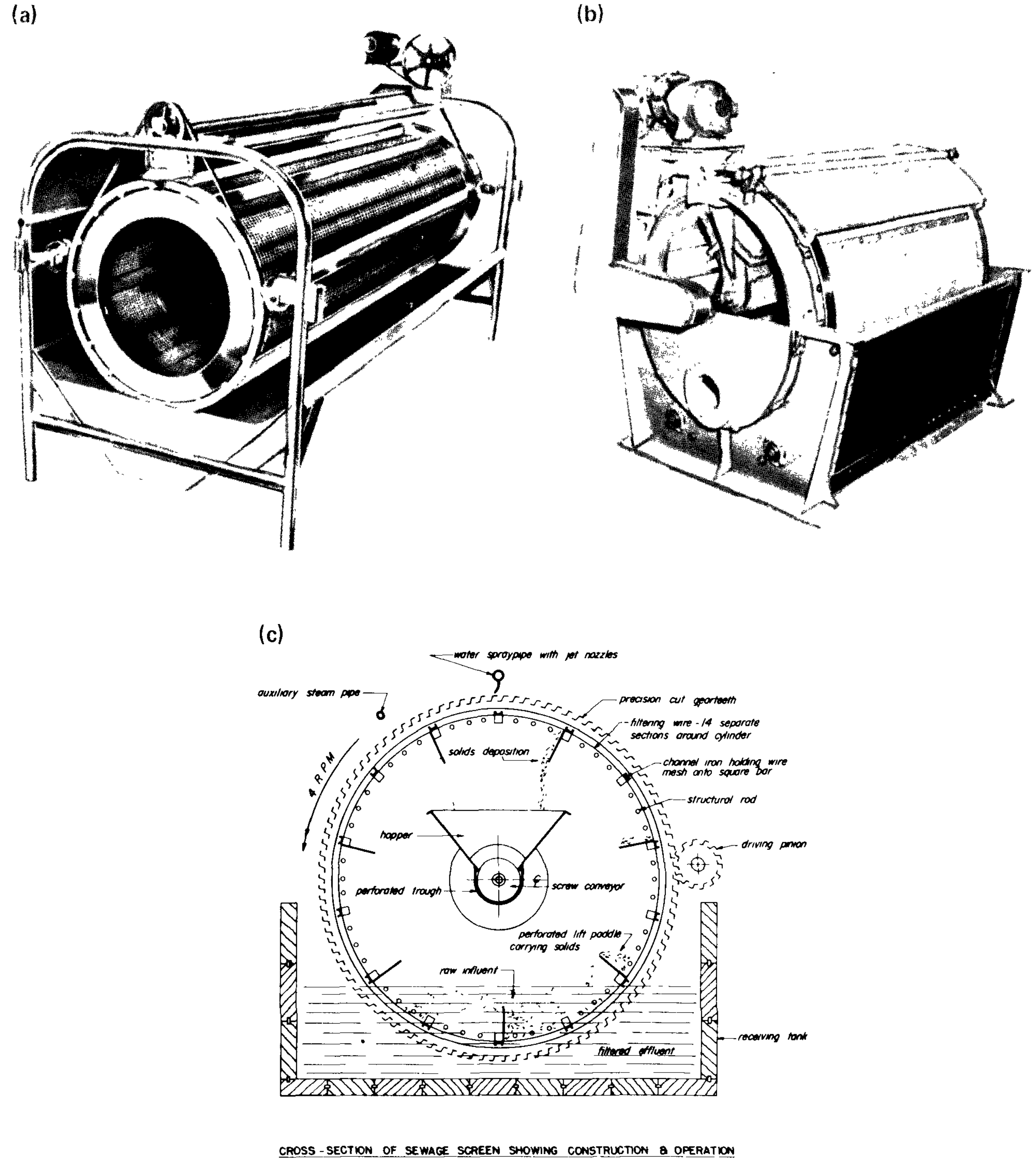


Figure II-6. Rotary screens for poultry wastewater processing· (a) rotary screen driven by external rollers; (b) rotary screen driven by external pinion gear, (c) cross section of rotary screen driven by piston gear.

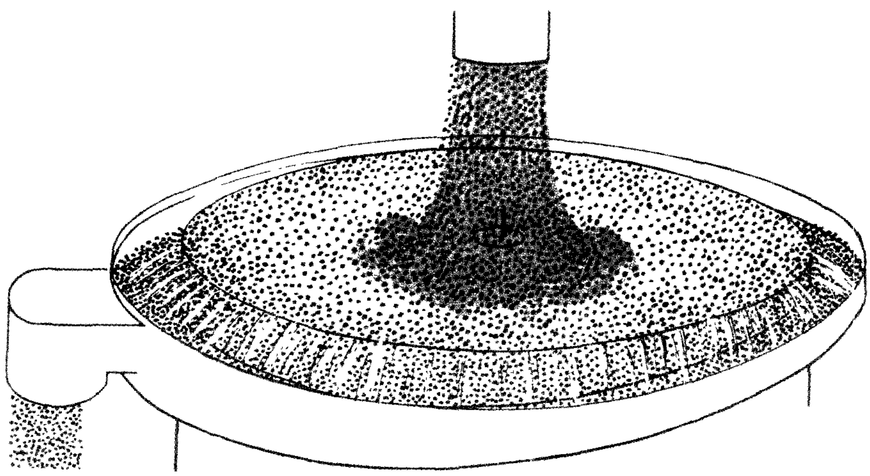


Figure II-7. Influx and discharge from spring-mounted motor-driven screen.

Part III

SEPARATION OF GREASE AND SUSPENDED SOLIDS

GRAVITY GREASE RECOVERY AND SEPARATION

Introduction

This section considers the requirements for design, guidance for design, available equipment, and the capability and limitations of four schemes of equipment arrangement for gravity grease recovery and separation. A hypothetical case was designed to establish a size parameter for discussion of the various tanks and mechanical equipment schemes. The approximate prices for the tanks and the mechanical equipment as enumerated are based on the sizing for the hypothetical case. These prices should be considered as "order-of-magnitude" rather than as fixed costs for specific applications. Such applications require specific estimates for equipment and construction costs; modifying the following information to accommodate a particular situation could produce very misleading results.

Design Criteria: Influent Characteristics

Rate of Flow. Hydraulically, this is the most important single criterion for design of the grease-separation unit. Rate of flow should be considered with respect to overall rate, total variations in rate, the magnitude of variations in rate, and the duration of variations in rate. The average flow from most poultry plants is on the order of 8 to 10 gallons per bird processed. Reports indicate that 75 percent of the flow can be expected during the processing day, the balance appearing during the cleanup period.

Temperature of Water. The temperature of water has some effect on gravity and grease separation; the variation of temperature may have a more detrimental effect than a uniform high or low temperature. Wide swings in temperature variation in gravity separation basins can result in temperature gradients and contribute to short circuiting in the basin. There are considerable supporting data to indicate that higher temperatures of water contribute to settling characteristics of solid heavy particles. Conversely, it would be in order to assume that lower water temperatures would contribute to greater grease separation.

BOD. BOD reduction may not be an objective of pretreatment; however, it is usually a side benefit of grease removal, since a large portion of the BOD contribution is from grease itself. BOD can vary from 1,200 ppm to approximately 400 ppm. Most municipal criteria limit the contribution to a 300-ppm level; hence, it may be desirable to use a grease recovery unit as a primary sedimentation basis in an effort to achieve BOD removal by the withdrawal of settleable solids.

Grease. Grease loads normally run in a range of 200 ppm, but they can vary to as high as 1,300 ppm. Most municipal plants require a grease loading not to exceed 100 ppm.

Settleable Solids. Most data indicate that settleable solids run on the order of 150 ppm in the effluent from poultry-processing plants. In any low-velocity or detention-type basin settleable solids will settle out. It may be desirable to remove the settleable solids and attempt to achieve a BOD reduction, or these solids may be returned to the flow going to the municipal treatment plant; in any event, there will be a certain amount of solids settling out in the basin.

Design Criteria: Factors Affecting Design

Detention Period. Usually this period is governed by other design parameters of the grease recovery basin. However, in some States where the basins are to be utilized as primary sedimentation basins in addition to grease removal, 1 to 2 hours of detention time may be required on the application.

Tank Depth. Theoretically, the more shallow a tank the faster either floating or settleable solids will separate; however, from data obtained in the field it has been found that depths of less than 6 feet are usually impractical. Hence, most State requirements will be on the order of 6 to 7 feet of tank depth. There are tanks of shallower depth in operation, no doubt operating satisfactorily. However, the shallower depth is not recommended because of the probability of upset by scouring or velocity currents.

Surface Area. Normally called "overflow rate," and probably the most commonly considered parameter of tank design, surface area is a combination of the horizontal velocity through the basin and the vertical velocity of the particle. A number of grease removal applications have indicated satisfactory removal with rates on the order of 1,440 gallons per day per square foot and even greater; however, if the separation unit is being applied as a primary separation, basin rates of 700 gallons per day per square foot or less should be applied. Many States will require rates not to exceed 700 gallons per day per square foot.

Particle Size. Basically, for particles with like specific gravity, the larger the particle size, the easier the separation will be. Hence the larger the grease particle the more rapidly it will float and the easier it will be to remove; the larger the particles of settleable solids, the more easily they can be settled out.

Density of Particles. Grease removal by gravity separation depends upon the density of the grease being lesser than the density of the water, so that the grease floats to the top.

Removal Facilities. May be either manual or mechanical; the mechanical mechanisms will be discussed in the following pages.

Flow Fluctuations. This is usually regarded as an undesirable effect, since it contributes to short circuiting and resuspension of particles; however, within certain ranges flow fluctuation can enhance the flocculation and agglomeration and, hence, the separation.

Pretreatment. There are several forms of pretreatment that may be considered, for instance grit removal, preaeration, flocculation and/or screening; however, these pretreatment processes and their effects should be considered independently for each particular application.

Hypothetical Case

Sizing Parameters. Let us assume

- 40,000 birds per day
- 10 gallons of processing water per bird
- 75 percent of flow occurring during 10-hour killing day
- 150 ppm grease load

- 450 ppm BOD
- State requirements dictating overflow rate of 700 gallons per day per square foot and 1½ hours minimum detention time

Selection of Type of Tank (Circular Versus Rectangular). Engineers are sharply divided as to the merits of rectangular versus circular separators for various purposes. Many engineers prefer rectangular to circular *gravity grease recovery* tanks; they believe that because of the increasing surface area traversed by the scum on a circular tank as it proceeds outward in a radial direction to the peripheral weir, the grease loses its cohesiveness. Others claim that the gradually reducing velocity of the flow as it moves radially outward improves grease separation as well as solids separation (a majority of engineers prefer circular tanks for settling flocculent solids). However, it is safe to say that, for gravity recovery of grease, the majority favor rectangular basins. In *dissolved air flotation* systems (see succeeding section), the two factions are about evenly divided, a slightly greater number favoring rectangular basins. Circular dissolved air flotation systems are described and illustrated in the last section of this part. In the preference of clarifiers *following biological treatment systems*, the circular clarifiers have a decided majority.

With the above sizing parameters, this example will utilize a pair of rectangular tanks with a common wall, 59.0 feet in length, each 10 feet in width and 6.0 feet average water depth.

Tank Construction--Concrete. Concrete tanks have the inherent advantages of lower overall maintenance and more permanent structure. However, some owners prefer to be able to modify their operation for future expansion or alterations or even relocation. The approximate cost for a pair of concrete tanks of the above sizing, assuming approximately 12-inch-thick walls, above grade, and nominal footings, and installed concrete costs of approximately $150 per cubic yard in place, would be $25,550.

Tank Construction—All Steel. All-steel tanks have the advantage of being semiportable, more easily erected in field, and more easily modified than the concrete tanks. The all-steel tanks require additional maintenance as a result of wear in areas of abrasion and corrosion or rusting in other areas. The approximate price for a pair of tanks of the above configuration in all-steel construction would be $26,800; a rough price for installation would be $2,900.

Tank Construction—Steel Walls. The tank utilizing all-steel walls and concrete bottom is probably the best compromise between the all-steel tank and the all-concrete tank. The advantages are the same as for steel; however, the all-steel tank requires footing underneath the supporting members, whereas with the steel-wall tank the concrete bottom forms the floor and supporting footings for the tank. The disadvantage is that this tank is not as readily movable as the all-steel tank. The approximate price for a pair of this nature, assuming a concrete pad approximately 18 inches thick and installed concrete cost of approximately $150 per cubic yard, would be $30,900, with an erection cost of approximately $1,900.

Four Possible Equipment Schemes for Grease Recovery: Functional and Cost Comparison

Four-Sprocket Collector with Scum Pipe. This unit is shown in figure III-1. Its advantages are that the scum is conveyed by the return run of the flights on the chain and the flight collector's continually pushing the scum toward the scum pipe. The sludge is conveyed at the same time by the same collecting mechanism to the sludge hopper for withdrawal to some other point. The disadvantage of this type of unit is that an operator is still required to operate the lever-type scum trough to admit the floating grease. The quality of operation depends upon the ability of the scum pipe operator to select the proper timing interval and tilt of the tube to obtain the best concentration of grease. Frequently the scum accumulates too rapidly to permit the operator to remove it often enough. Another disadvantage is the possibility that grease can adhere to the flights on the return run; when carried beneath the scum trough and baffle it may eventually float up and go over the weirs into the effluent. The approximate price for this unit, including the complete sludge collector drive and the scum trough, would be approximately $12,500[1] with an approximate installation cost of $3,000.[1]

Four-Sprocket Collector With Flight-Type Skimmer. This collector consists of the four-sprocket arrangement as discussed above with the addition of a flight skimmer as shown in figure III-2. This unit has basically the same advantages as those listed above, with the added advantage of a flight-type collector that conveys the dewatered grease to the horizontal trough to flow into the scum pit. Basically, the only disadvantage to this unit is that the return flights of the horizontal sludge collector can again carry grease down behind the scum skimmer, from which it may eventually float up and over the weirs. The approximate price for this arrangement would be $23,000;[1] the approximate price for the installation of this equipment in one of the above tanks would be $3,600.[1]

Three-Sprocket Collector with Flight Skimmer Full Length and Cross Screw Conveyor. This equipment arrangement, shown in figure III-3, is probably the best possible assemblage of gravity grease removal equipment. The advantages are that the three-sprocket collector conveys the sludge and therefore circumvents the problem of grease adhering to the flights. Another advantage is that the skimmer travels the full length of the surface of the tank, bringing the grease up over the beaching plate and into the cross scum trough; the utilization of a ribbon-type screw conveyor in the cross trough permits the positive conveyance of the grease to the collecting pit. The additional advantage of this unit is the low requirement for operator attention; these units can either be placed on a timer or operated continuously, the operator checking them only occasionally and utilizing normal maintenance and housekeeping procedures. The approximate price for these units is $32,500[1] and the approximate installation cost is $5,700.[1]

Helical Scum Skimmer. This type of mechanized skimmer, shown in figure III-4, is a compromise with the flight-type skimmer mentioned above. The unit is slightly less expensive and slightly more economical to maintain than the flight skimmer; however, it does not have the volumetric capacity of the flight-type skimmer.

Maintenance and Operation Requirements

Overall Arrangement of System Elements. Most gravity grease recovery units use no additional chemicals, flocculants, or polymers to achieve the grease separation. Therefore, there is no requirement for design or maintenance of a chemical feeding system. The gravity grease recovery unit is quite simple in construction and operation, alleviating the need for sophisticated or highly trained operators.

In gravity grease recovery and separation, as with any system of wastewater treatment, the overall system must be considered in addition to the individual elements. Particular attention should be given to maintaining low turbulence in the flow and minimizing pumping.

Housekeeping. Each gravity grease recovery system requires a certain amount of housekeeping. After operating for a few months, the equipment becomes coated with grease. It is difficult, if not impossible, to ascertain the need for maintenance when the parts are not visible. Hence, there is a need for scraping, scrubbing, steam cleaning, and in some cases high-pressure hosing, to assist the

[1] See "Design Criteria: Factors Affecting Design."

people responsible for maintenance in keeping the units operational. Cleanliness also helps in the reduction of odors and elimination of odor-producing bacteria.

Mechanical Maintenance. The day-to-day observation and the periodic checking of alignment, grease levels in speed reducers, and greasing of bearings are natural requirements of any wastewater operation. Eventually the chains will wear and require replacement. The replacement interval can be lengthened considerably by utilization of timers. This equipment basically has a wear life proportional to the hours of use; hence, if a unit is placed on a timer, a longer wear life can be expected. A high percentage of grit in the wastewater may accelerate the wearing of the components; the grease will tend to hold the grit in the wearing part of the unit, acting as a lapping compound and accelerating the wear.

Pilot Plants

The use of pilot plants for grease recovery and/or other wastewater treatment design cannot be overemphasized. The most important information obtained from pilot plant studies is that the plant must be operated with a flow representative of that for which the ultimate plant will be designed. One of the most frequent errors in the use of pilot plants for design purposes is the application of the pilot plant data to a flow different from that ultimately intended to be treated.

Most major manufacturers have pilot plant equipment available on rental terms.

DISSOLVED AIR FLOTATION

Dissolved air flotation is a waste-treatment process in which oil, grease, and other suspended matter are removed from a waste stream. This treatment process has been in use for over 15 years and has been most successful in removing oil from waste streams. Its principal early use was, as it still is, the removal of oil from petroleum refinery wastewater. Another natural area for application of this treatment system has been the removal of contaminants from the food-processing-plant waste streams. One of the very first applications of this treatment system was for this purpose.

Basically, dissolved air flotation is a process for removing suspended matter from wastewater that uses minute air bubbles, which upon attachment to a discrete particle reduce the effective specific gravity of the aggregate particle to less than that of water. Reduction of the specific gravity for the aggregate particle causes separation from the carrying liquid in an upward direction. As figure III-5 suggests, the particle to be removed may have a natural tendency either to rise or to settle. Attachment of the air bubble to the particle induces a vertical rate of rise noted as V_T.

Figure III-6 illustrates the basic design considerations of the flotation unit. The measurement of the parameter V_T will be discussed later. Since the waste flow must pass through a treatment unit, the particle to be removed will have a horizontal velocity. Certain criteria have been established for limits of the parameter V_H, which sets the width and depth of the treatment unit. Therefore, as figure III-6 suggests, the effective length of the treatment unit is directly proportional to the horizontal velocity and depth and inversely proportional to the vertical rate of rise of the particle to be removed.

The mechanics of operation for a dissolved air flotation unit are illustrated in figure III-7. It can be noted that a portion of the clarified effluent is pressurized by a recycle pump. This recycled flow is pumped to a pressure tank into which air is injected. In the pressure tank at approximately 40 psig, the recycle flow is almost completely saturated with air. The pressurized recycle flow, containing the dissolved air, leaves the air saturation tank and flows through a pressure reduction valve.

A 40-psig pressure drop occurs at the pressure reduction valve, causing the pressurized flow stream to relinquish its dissolved air in the form of tiny air bubbles. This air-charged recycle flow is then blended with the raw process flow to effect attachment of the air bubbles to the oil and other suspended solids to be removed. The combined flow stream (raw flow plus recycle flow containing the air bubbles) is mixed and uniformly distributed over the cross section of the basin.

As the incoming flow travels to the effluent end of the basin, separation of the oil and solids from the associated liquid occurs. Solids accumulate at the water surface and form an oily sludge blanket. Clarified liquid flows over the effluent weir and into a wet well. From the effluent wet well, a portion of the effluent is recirculated. The remainder of the effluent is removed from the basin for subsequent treatment or discharge. The floated scum blanket of separated solids can be removed from the basin by skimmer flights traveling between two endless strands of chain. Since the influent stream may also contain small amounts of heavy solids, such as grit, which are not amenable to flotation, provision must also be made for solids removal from the bottom of the unit.

The foregoing discussion illustrates the recycle method of injecting the air bubbles into the waste stream. Figure III-8 shows all three methods of dissolved air injection currently used. Total pressurization, as the name implies, occurs when the total waste flow is pressurized before entering the treatment unit. Partial pressurization is a method whereby a portion of the waste flow is pressurized and mixed with the remaining raw flow before entering the treatment unit.

To obtain optimum treatment with some wastes, it has been necessary to use chemical pretreatment before dissolved air flotation. The necessity for use of chemical conditioning is normally associated with a high degree of emulsification of the oil or grease matter in waste stream flow. It is, therefore, a requirement to break the emulsion and form a floc to absorb the oil or grease. It has been shown (fig. III-9) that increasing the particle size increases the rate of separation. Flocculation as a means of promoting particle growth preceding flotation contributes to the effectiveness of the flotation process where chemical conditioning is used. The points of chemical injection and the possible use of flocculation associated with the three methods of air injection are shown in figure III-10.

The use of steel-package dissolved air flotation units lends itself to application in the poultry-processing industry. This arrangement provides an economical, flexible design that requires minimal construction cost and area investment (fig. III-11). Most manufacturers of dissolved air flotation units have a complete line of steel tank units to meet a wide variety of flow conditions.

The use of steel-package units lends itself equally well to those applications requiring flash mixing and flocculation as a part of chemical pretreatment.

In the following discussion, a steel-package Model No. 6020 with flash mix and flocculation compartments has been used to illustrate the costs associated with this type of unit. The capital cost of this unit would be approximately $37,500, which would include the following equipment:

- Flash mixer and drive
- Flocculator and drive
- Two-shaft surface skimmer and drive
- Screw conveyor, sludge collector, and drive
- Complete steel tank

- Pressure tank and associated air central system
- Recycle pump
- Compressor
- Recycle piping

Table III-1 lists the operating horsepower included in the above-described unit. Based upon a 10-hour-day, 5-day-week operation, costs of running Model No. 6020 for 52 weeks are shown for electrical costs at 1 cent per kW-h and 1.5 cents per kW-h.

Table III-2 illustrates typical results from the treatment of poultry-processing wastes by dissolved air flotation with and without chemical treatment. The raw waste characteristics and treatment results shown are for grab samples from a unit in Alabama. The characteristics of this waste somewhat exceed those of waste normally encountered in this application; the necessity of chemical treatment is therefore evident for this particular application. The raw flow to this unit is 150 gpm; based upon a lime dosage of 100 mg/l, the total lime use in a single 10-hour working day would be 76 pounds. Extending this use to a continuous operation of 5 days per week, 52 weeks per year, the yearly lime use would be approximately 20,000 pounds. The cost of this amount of lime would be about $1,000 per year; capital cost of a simple lime feed system would be between $6,000 and $8,000.

As is the case with most industrial waste, treatability studies should be conducted not only to determine the design parameters for a flotation unit, but also to determine whether chemical treatment is necessary to meet treatment objectives.

Pilot dissolved air flotation units are available from most manufacturers for treatability studies. The rental cost varies, but the normal rate is approximately $500 per month.

A laboratory bench scale test procedure developed to simulate the dissolved air flotation process has been used most successfully in the determination of design parameters for an air flotation unit.

This flotation test (fig. III-12) is used to determine the suspended particle rise rate (V_T), which is the most critical design parameter in the design of the flotation unit. The rate is determined by filling the pressure cell with liquid to simulate closely the recirculation of the unit effluent of pressurization in a full size unit; this recycle water should be developed by several previous flotation runs.

Table III-1—*Operating horsepower for Rex Chainbelt Model 6020*

Item	Horsepower
Flash mixer	0.5
Flocculator	.5
Skimmer	.5
Bottom screw	.5
Recycle pump	7.5
Compressor	1.5
Total	11.0

Note.—Based on a 10-hour-day, 5-day-week operation, yearly operating costs equal: $214, at 1 cent per kW-h; and $321, at 1.5 cents per kW-h.

Table III-2.—*Typical operational results from treatment of poultry-processing wastes by dissolved air flotation with and without chemical treatment*

Raw waste	mg/l
BOD_5	2,460
Suspended solids	946
Oil and grease	200

Results

Run number	Percent recycle	Chemicals	Percent removal	
			BOD_5	Suspended solids
1	33	None.	38	54
2	50	None.	39	62
3	33	Lime, 100 mg/l.	57	81
4	33	Alum, 300 mg/l.	33	94

This liquid is then injected with air until a pressure of over 40 psi is obtained; the cell is then shaken vigorously to insure that the air is put into the solution. The pressurized liquid is then introduced into the waste. The exact amount of pressurized liquid is determined by trial and error for best results. As the minute bubbles are released from solution, they attach to the suspended particle and oil and rise to the surface. After flotation is complete, a sample of the effluent is taken and analyzed. During the test, observation of the rise rate of the major portion of the solid material with respect to time is recorded. From a graphic plot of these data a rise rate can be calculated. This rise rate, along with factors for turbulence and short circuiting, is used in the selection of the basic size necessary to accomplish treatment required.

OTHER SYSTEMS

Whereas the preceding section was limited to a discussion of rectangular dissolved air flotation systems, it should be noted that the same principle is applied to circular-shaped tanks by a number of equipment manufacturers. These tanks are similar to conventional clarifiers with center baffled inlet, peripheral weir, bottom sludge removal scrapers, and surface skimmer arms discharging to a surface scum trough. The pressurized air recycle arrangements are the same as those used in rectangular tank systems. The first accompanying flow diagram (fig. III-13) shows a small poultry plant pretreatment system at Allentown, Pa., using a circular flotation tank. In this instance a portion of the effluent of the flotation tank is pressurized, aerated, and returned directly to the flotation tank. In the second instance, at Fayetteville, N.C. (fig. III-14), a portion of the effluent is again recycled, but in this instance the recycle is not pressurized and aerated. Rather, the recycled effluent is recycled to the screened raw waste; the entire screened raw waste plus recycle are then pressurized, aerated, and discharged to the flotation cell. This is similar to the "total" pressurization illustrated at the top of figure III-10, with the addition of recycle from effluent to influent. The costs shown include the flotation tank complete with pump, air saturation tank, and mixing tank, and mixer but do not include the screen or the cost of erection.

In some cases, *vacuators* have been used to separate floatables in pretreating poultry plant wastewater. Vacuators are basically completely enclosed concrete tanks where a vacuum is applied as the wastewater passes through the tank. The vacuum enhances flotation in a three-product separation similar to air-pressurized flotation. The need for complete enclosure limits observation of operating characteristics. Designs range from 300 gpm to 2,000 gpm per unit. As stated in "Costs" in part I, a vacuator installed in Arkansas to treat 1,250,000 gallons daily cost $45,000 in 1969.

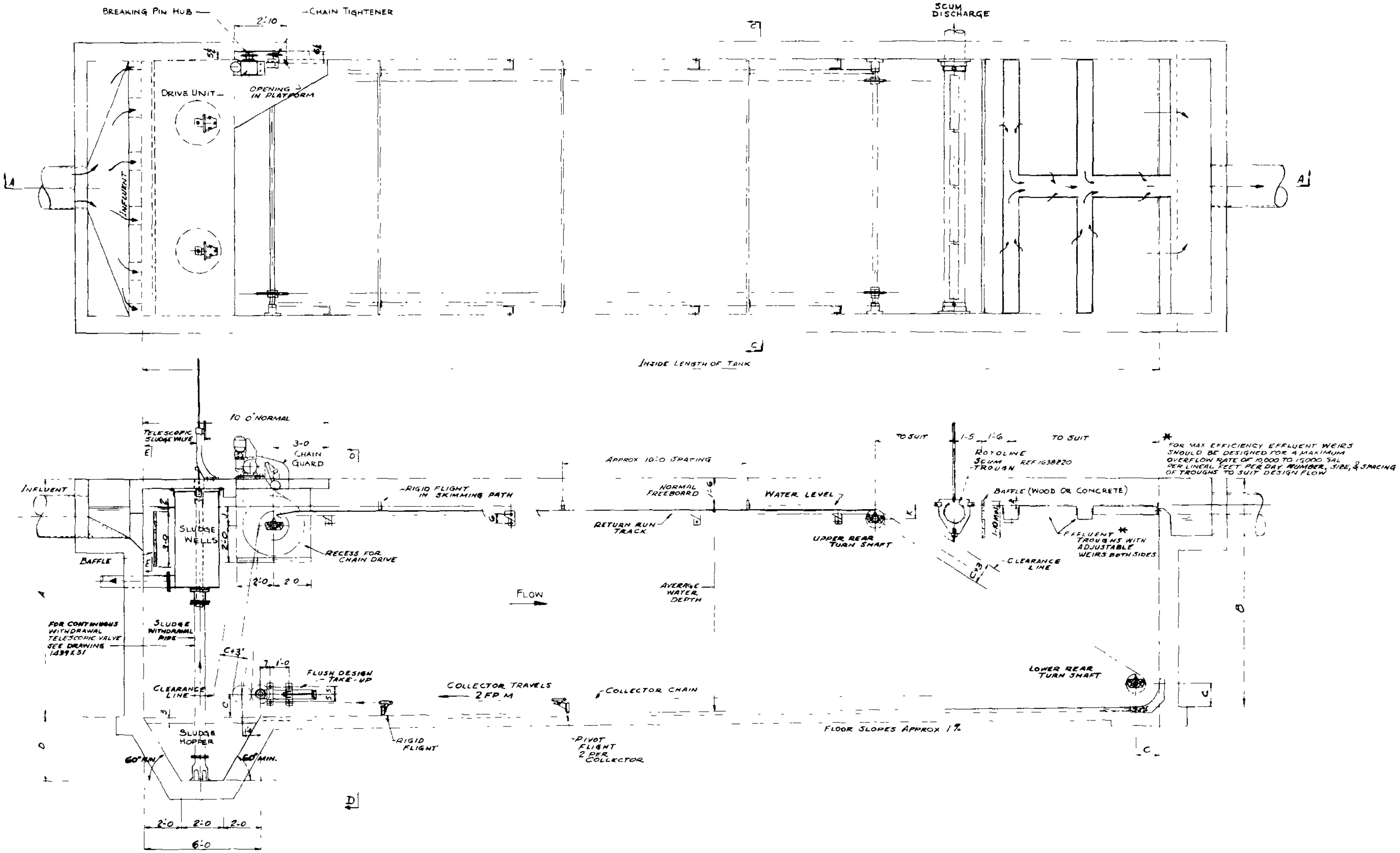


Figure III-1. Four-sprocket collector with scum pipe for grease recovery. (Courtesy of the Link-Belt Company.)

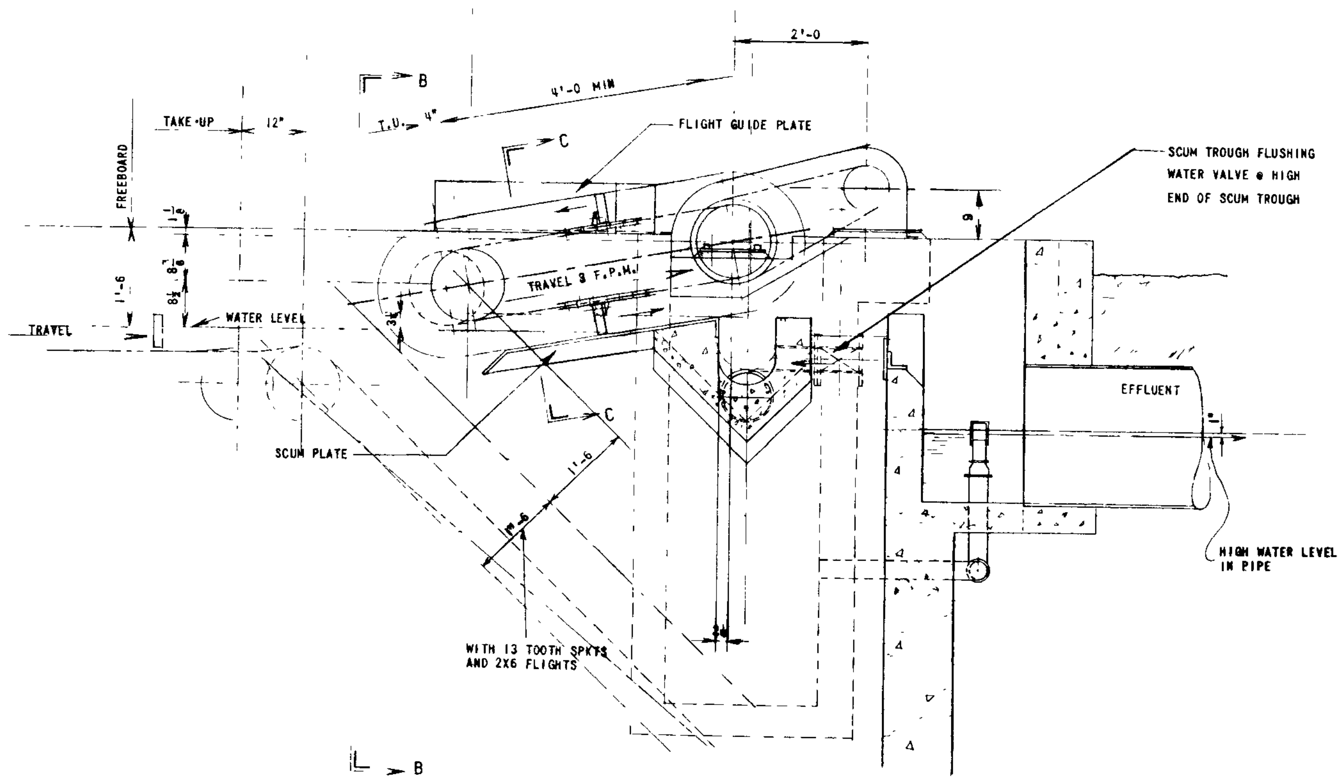


Figure III-2. Four-sprocket collector with flight-type skimmer for grease recovery. (Courtesy of the Link-Belt Company.)

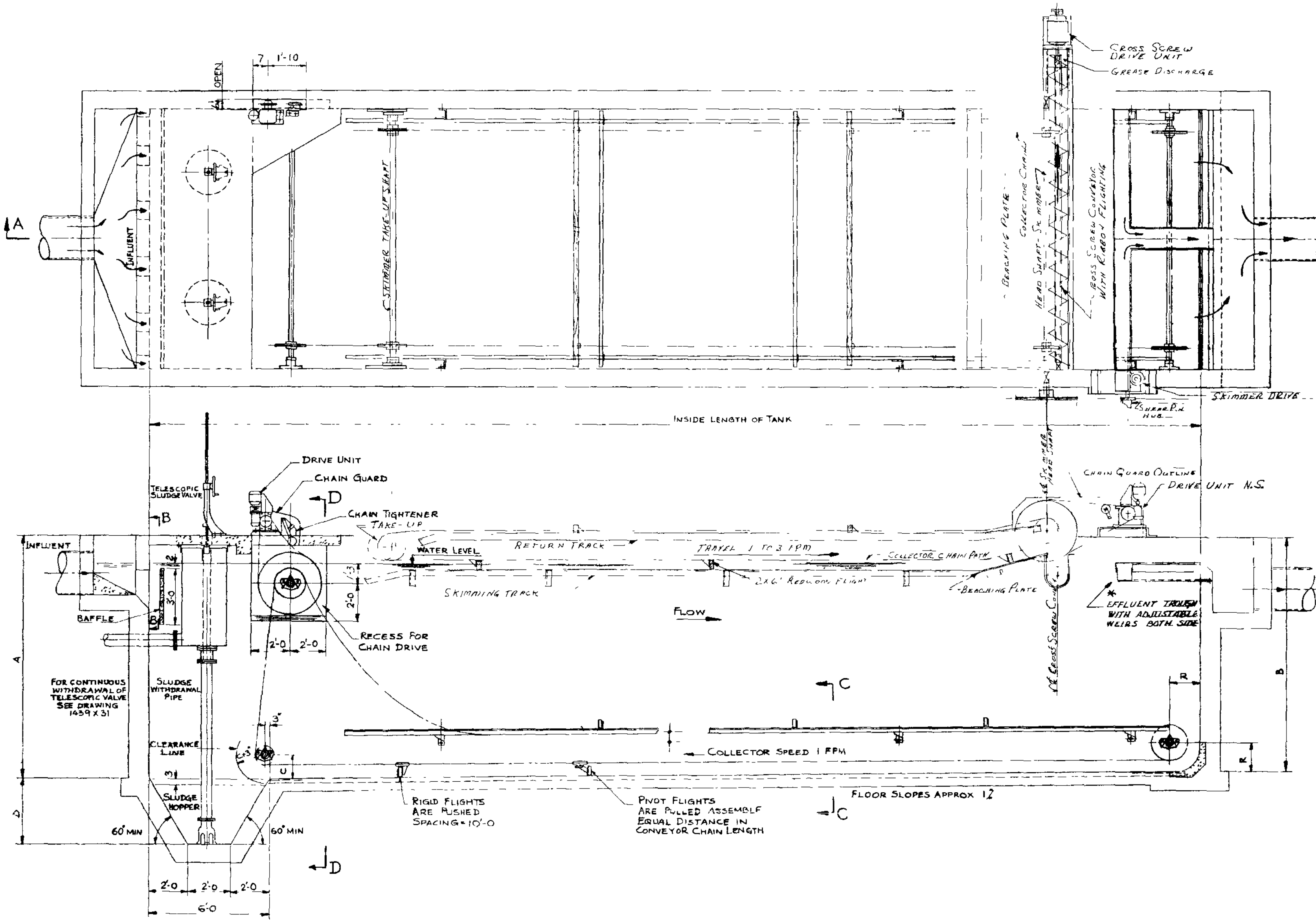


Figure III-3. Three-sprocket collector with flight skimmer full length and cross screw conveyor. (Courtesy of the Link-Belt Company.)

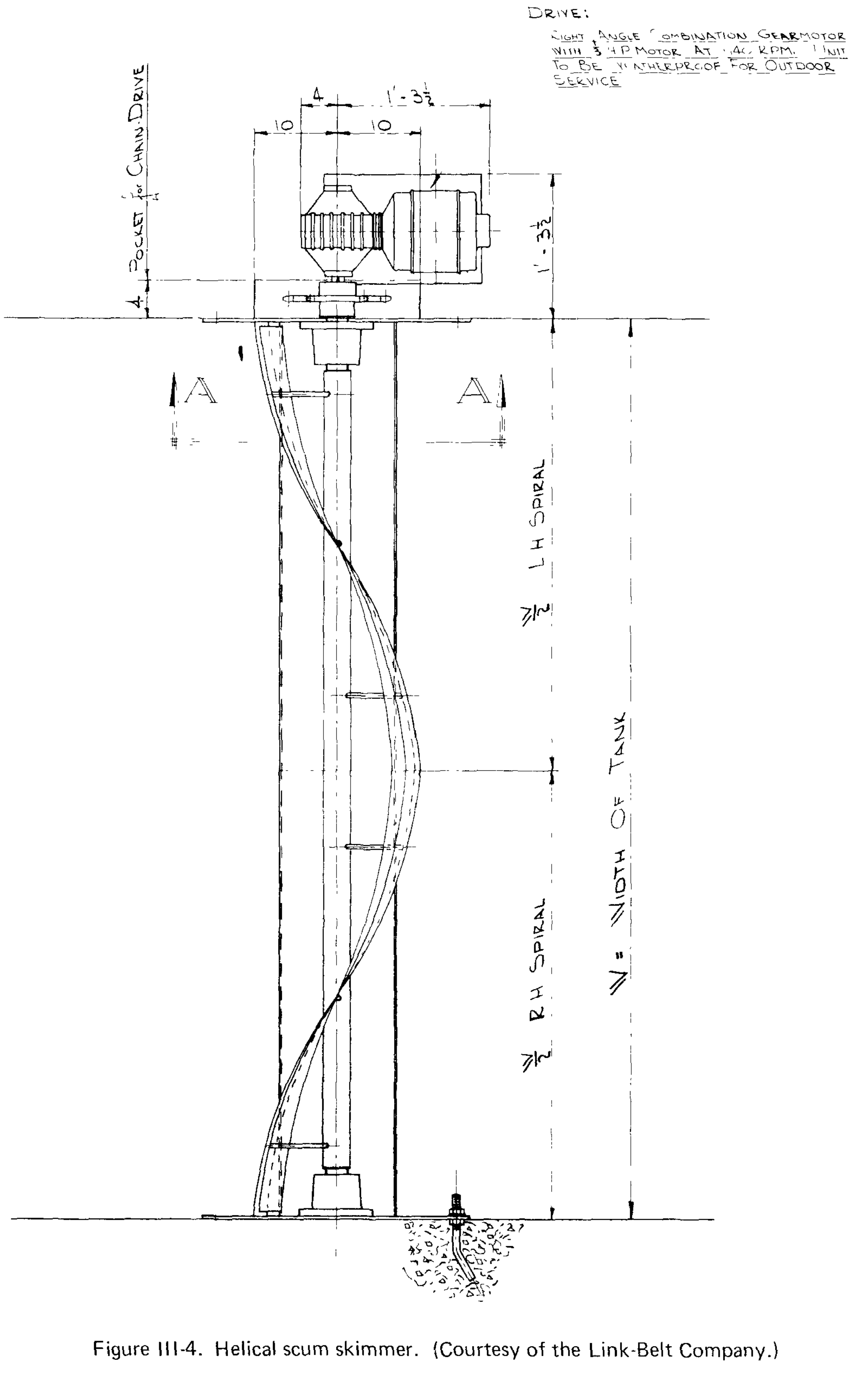


Figure III-4. Helical scum skimmer. (Courtesy of the Link-Belt Company.)

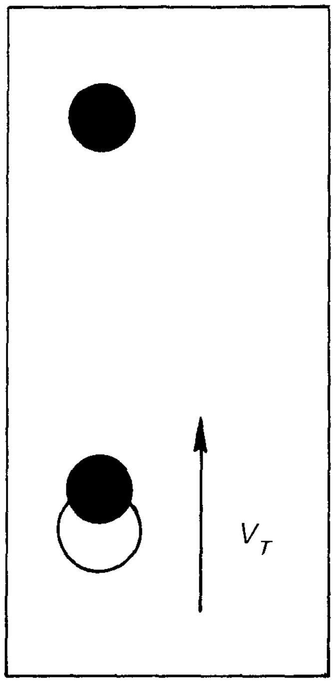


Figure III-5. Separation of particle from wastewater by dissolved air flotation (V_T = vertical rate of rise).

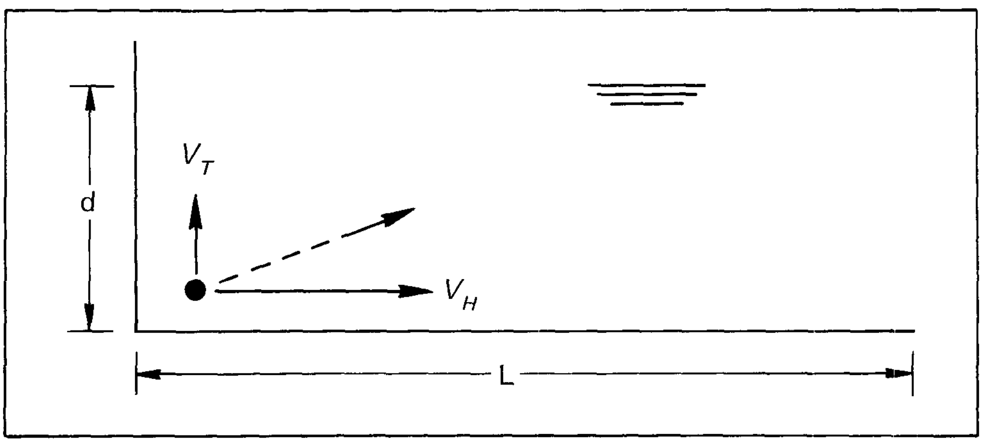


Figure III-6. Basic design considerations of flotation unit. (V_T = vertical rate of rise; V_H = horizontal velocity; L = length of treatment unit.)

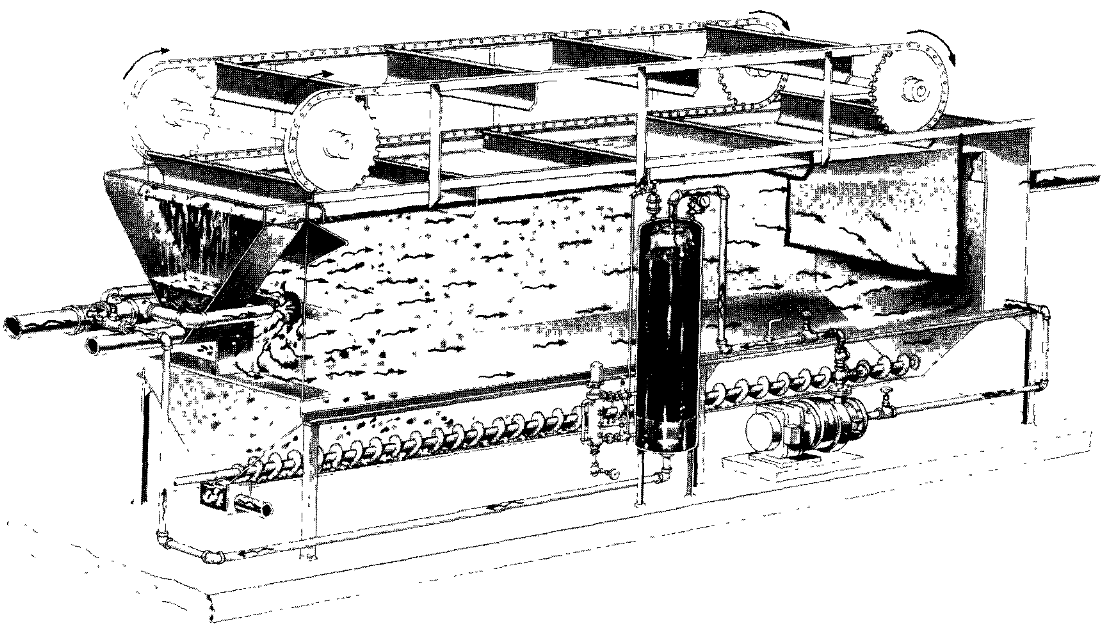


Figure III-7. Dissolved air flotation unit: mechanics of operation.

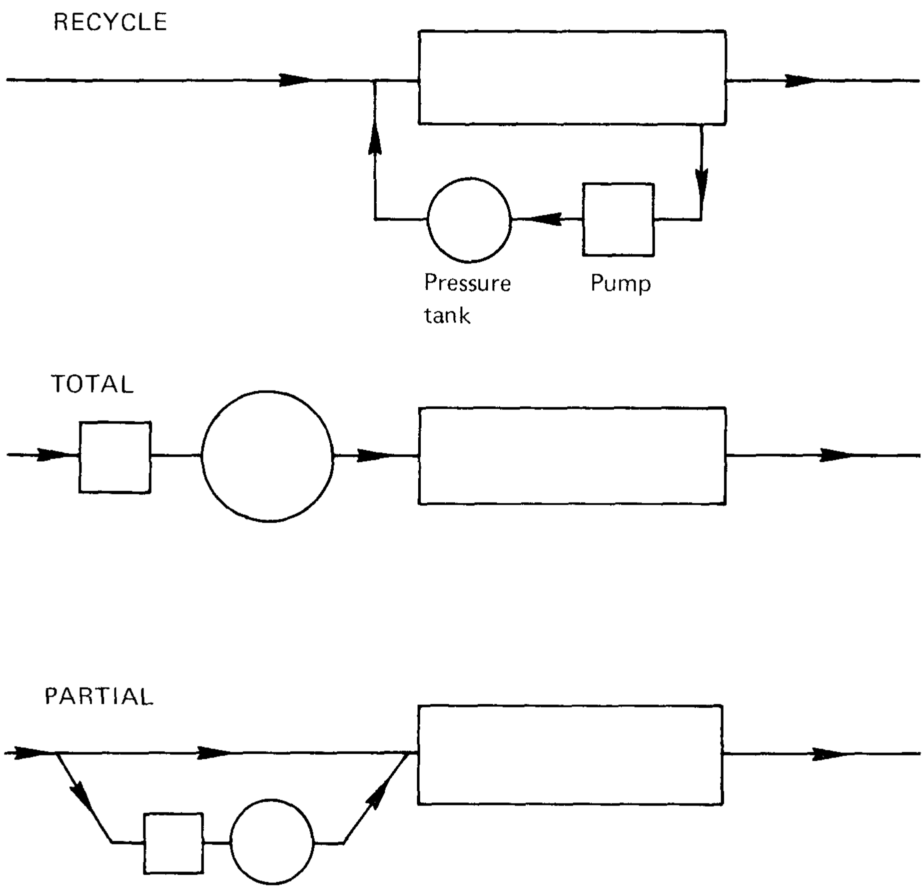


Figure III-8. Injecting air bubbles into the waste stream: recycling, total pressurization, and partial pressurization.

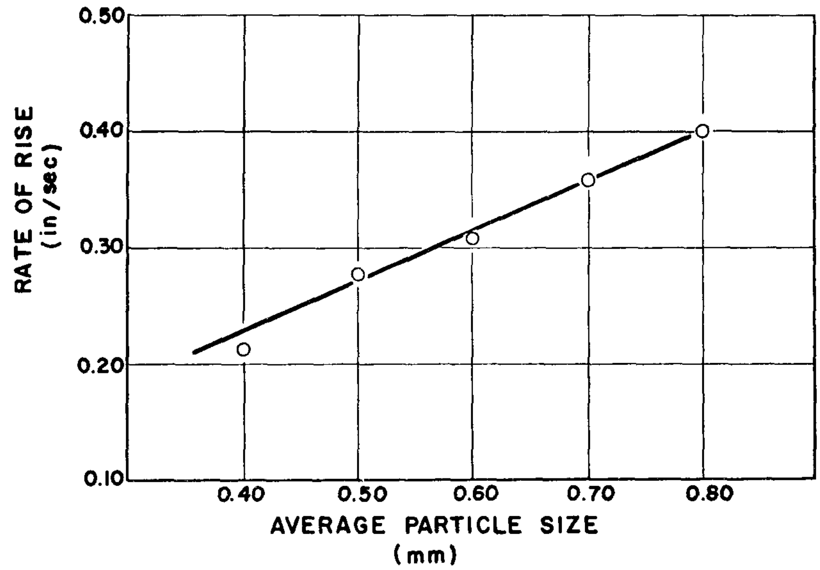


Figure III-9. Effect of average particle size on rate of rise: 100 ppm lime; 20 ppm bentonite; 20 percent recycle.

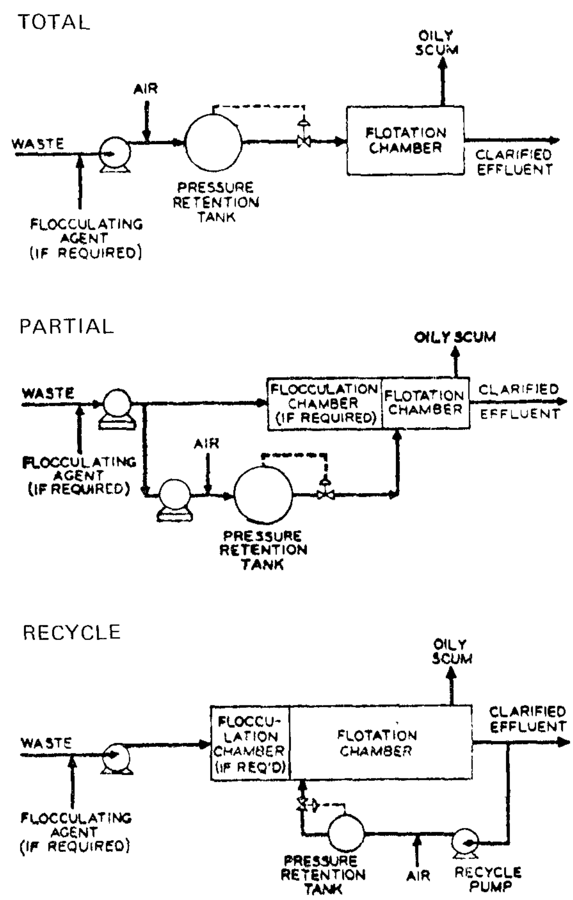


Figure III-10. Points of chemical injection and use of flocculation associated with total and partial pressurization and recycling.

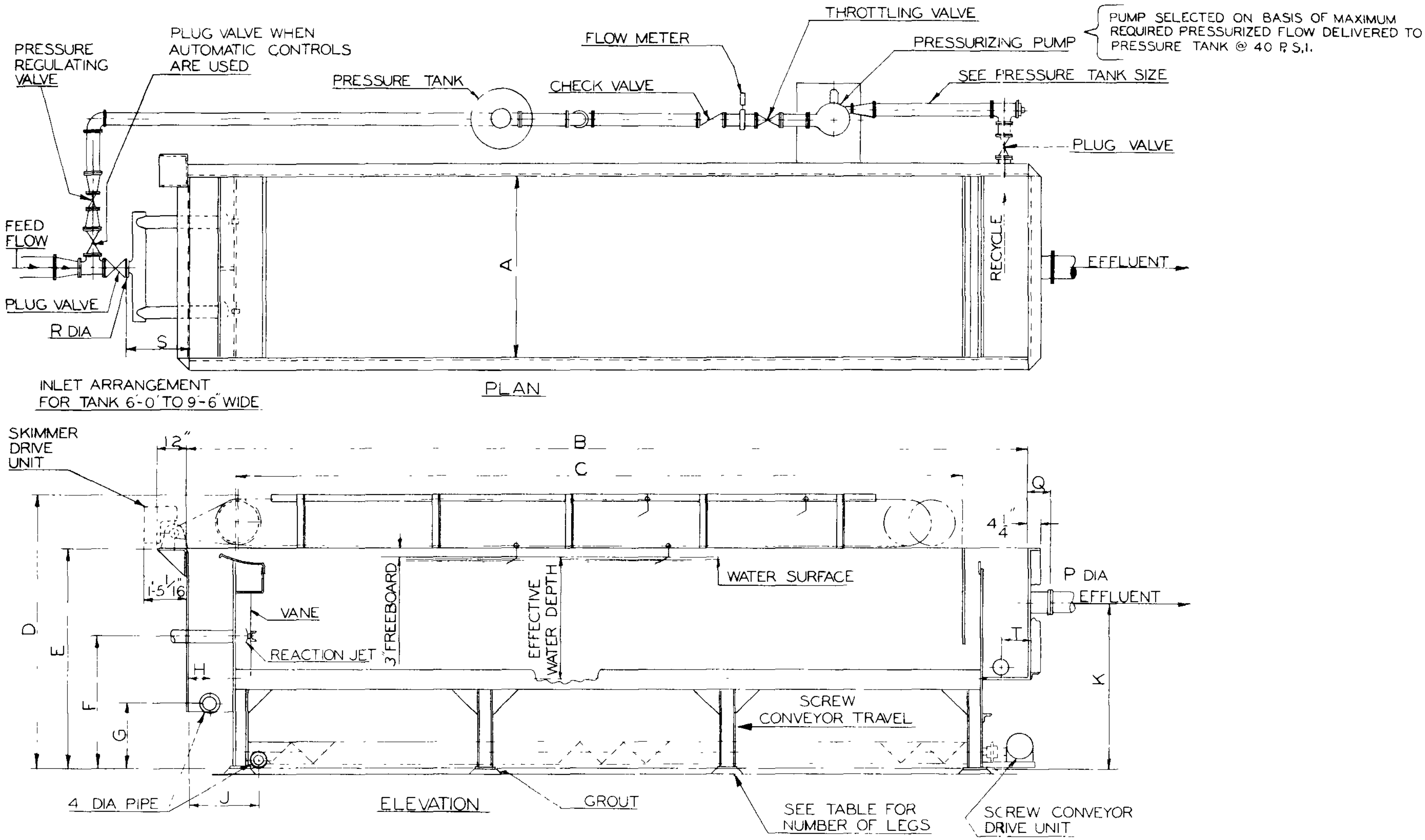
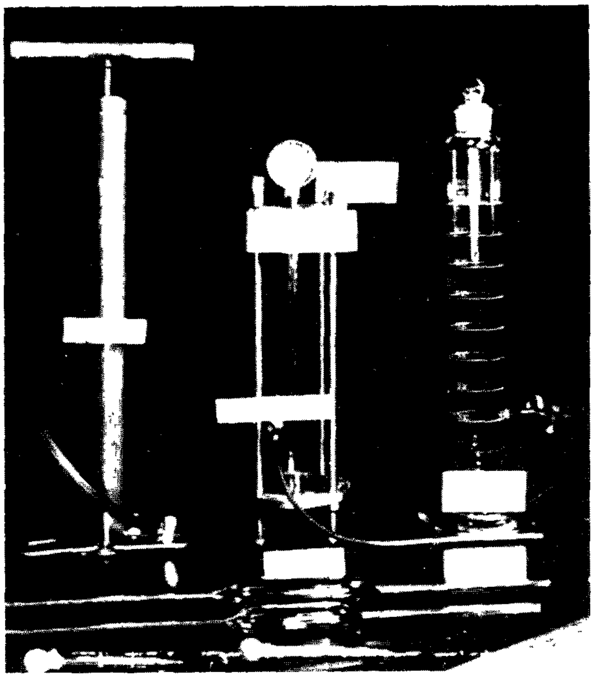
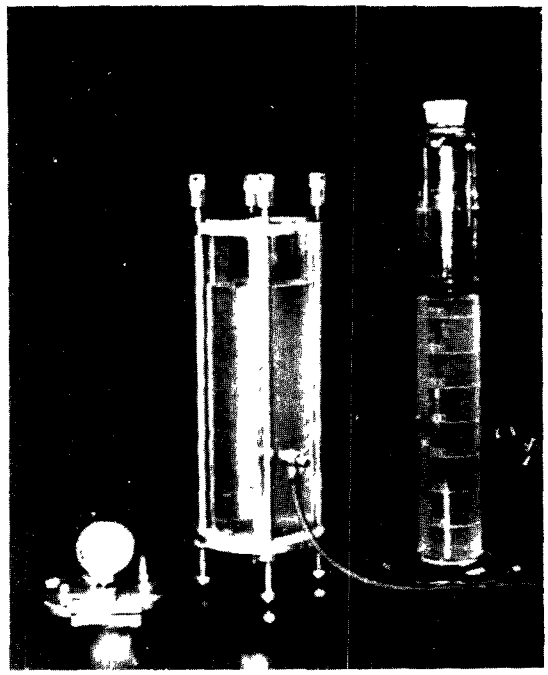


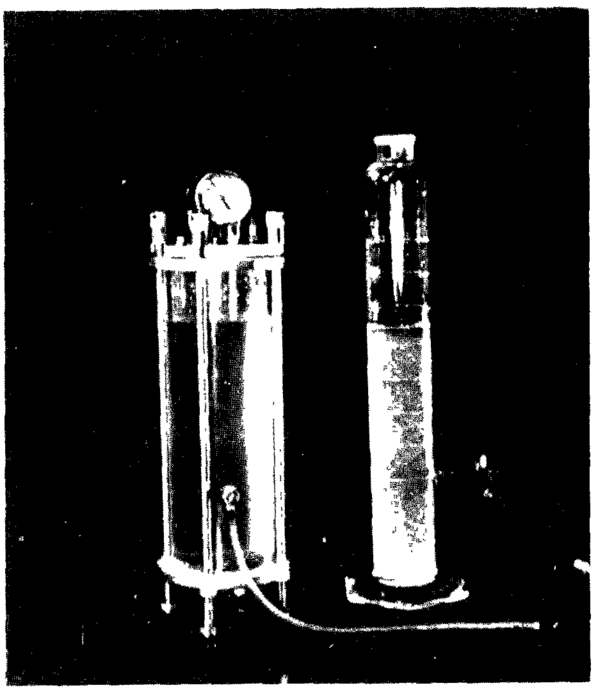
Figure III-11. Steel tank with skimmer and sludge-removal facilities. (Courtesy of Rex Chainbelt Inc.)



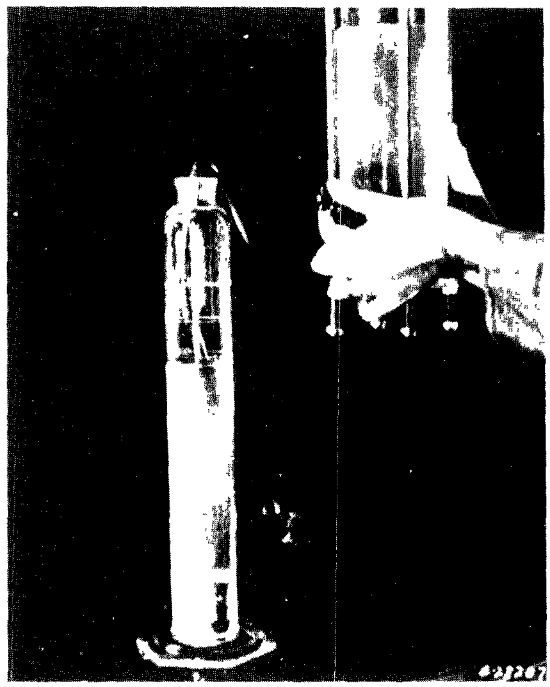
Component parts—Rex Flot-Aire Kit



Flot-Aire pressure cell with clarified effluent
Glass cylinder with raw waste

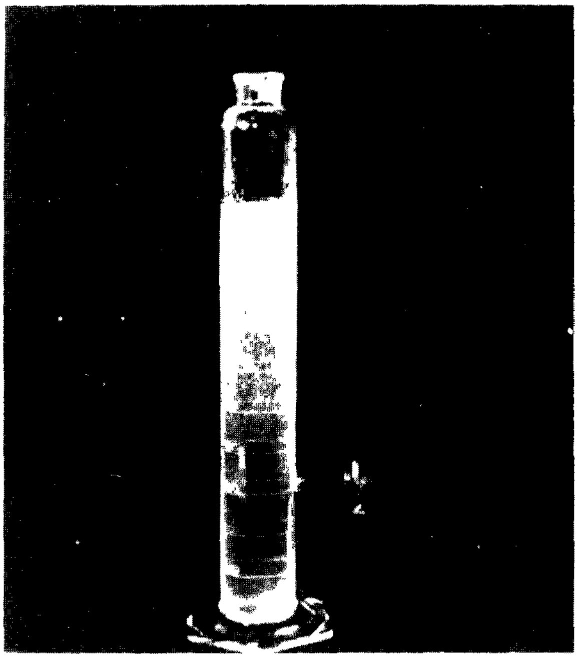


Clarified effluent in Flot-Aire pressure cell pressurized to 40 psi

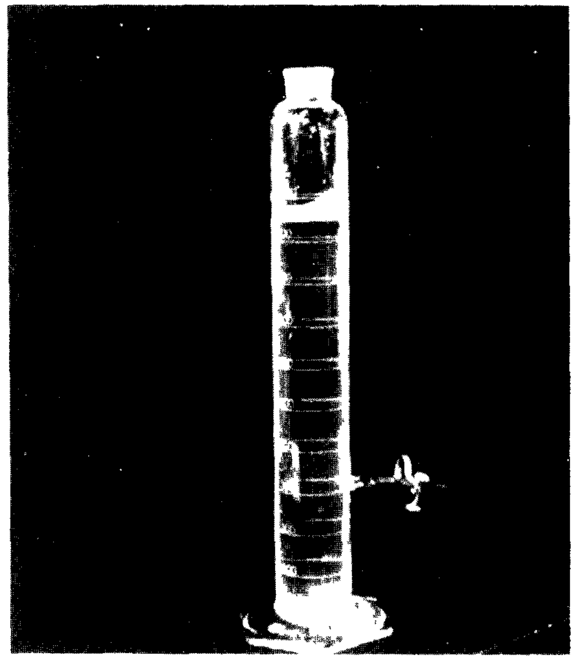


Pressurized effluent introduced to raw waste

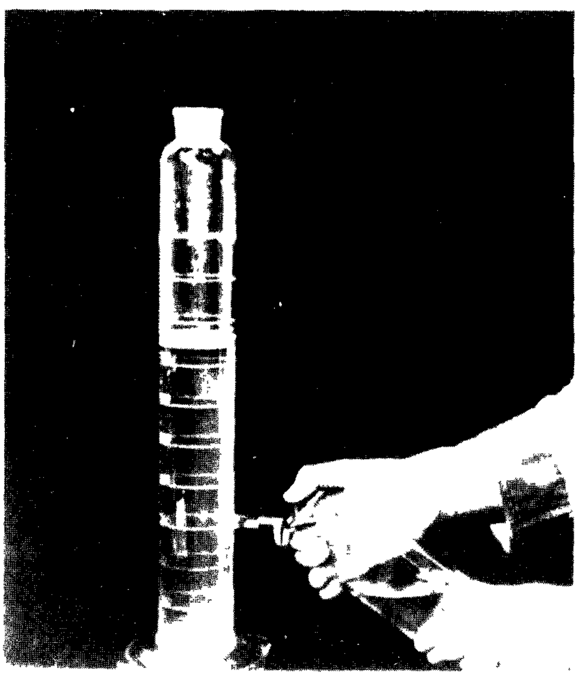
Figure III-12. Laboratory bench scale test to simulate dissolved air flotation process. (Courtesy Rex Chainbelt Inc.)



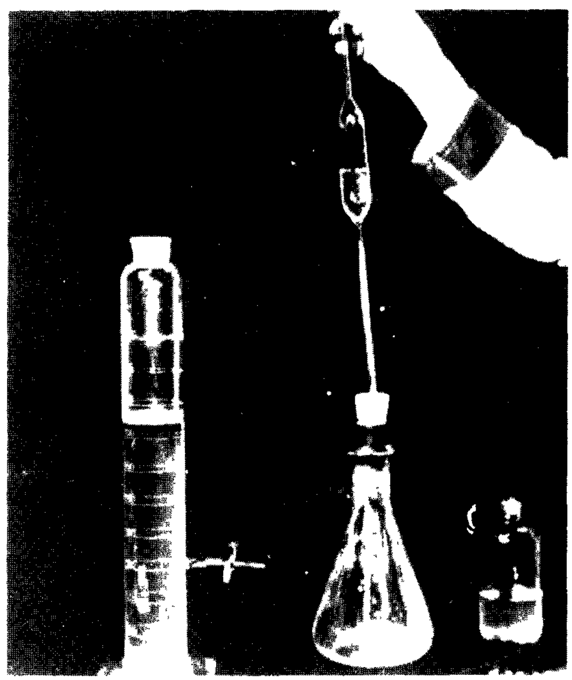
Minute air bubbles floating waste material to surface of cylinder



Flotation complete in cylinder



Clarified waste sample being withdrawn from cylinder



Analysis made of clarified waste

Figure III-12. Laboratory bench scale test to simulate air flotation process —*Continued*

See Figure 2 - Data Sheet 315-10.804 for Rex Float-Treat Test Kit.

A. Assume that a recirculation ratio of 0.33/1 is to be tried.

1. Place 750 ml of a representative sample of the waste in a one liter graduated glass cylinder. (See Figure 3, Data Sheet 315-10.804.)

2. Fill the Float-Treat Pressure Cell approximately three-fourths full with liquid. (See Figure 3, Data Sheet 315-10.804.)
   (It is desirable that the operation of the Float-Treat Pressure Cell closely similate the recirculation of effluent as used in the Float-Treat Flotation System. The returned effluent (recycle water) may be developed by repeated flotation of several different portions of raw waste. After the recycle water has been developed and used in the flotation tests, samples may then be withdrawn for chemical analyses.)

3. Secure the cover gasket and cover of the Float-Treat Cell, making certain all the valves are closed.

4. Inject air into the cell until a pressure of 40 psi is attained and maintained during testing. (See Figure 4, Data Sheet 315-10.804.)

5. Shake the cell vigorously for thirty seconds.

6. Release 250 ml of the liquid which has been pressurized into the graduated cylinder. (See Figure 5, Data Sheet 315-10.804.) The volume of liquid in the graduated cylinder then totals 1000 ml (750 ml raw and 250 ml pressurized). The ratio of volumes of recycle water to the raw waste is termed the recycle ratio. This ratio is expressed in percent and is termed the recycle rate. Thus, the recycle rate used in this test is 33%. The most suitable recycle rate can be determined by repeated tests at varying rates of recycle and usually is not less than 20% and no more than 50%. To facilitate the introduction of the air-charged recycle water to the graduated cylinder, a rubber tube may be connected to the petcock on the pressure cell. After clearing the rubber tube of air, (Allow some liquid to escape through the tube by opening petcock. Sufficient liquid should be removed until it has a milky appearance) the air-charged recycle water is introduced through the rubber tube into the graduated cylinder. The end of tube should be placed near bottom of the cylinder. (See Figure 5, Data Sheet 315-10.804.)

Figure III-12. Laboratory bench scale test to simulate air flotation process.—*Continued*

The air bubbles rise through liquid in a manner similar to that in the Float-Treat flotation system.

7. Allow the contents of the graduated cylinder to come to rest and observe the flotation. (See Figure 6, Data Sheet 315-10.805.) Allow sufficient time for the rising solids to come to the surface of the liquid. Usually ten minutes will be sufficient time for the flotation to be completed. (See Figure 7, Data Sheet 315-10.805.)

8. After the flotation is completed, a sample of the raw waste and treated waste should be taken for analysis. (See Figures 8 and 9, Data Sheet 315-10.805.) The treated waste should be carefully withdrawn from the graduated cylinder either through the use of a petcock installed in the side and near the bottom of the cylinder or through the use of a siphon inserted in the cylinder. Sufficient liquid should be withdrawn to complete the desired analysis, however, care should be taken to avoid the break up of the skum blanket.

9. Should chemical flocculation with flotation be desired, the chemical may be added into the raw waste after step "1" is completed, flocculation may be carried out, for convenience, in another vessel. Care should be taken not to break up the floc when transferring the waste to the cylinder. Enough time for flocculation should be allowed before introducing the air-charged recycle water. Under appropriate conditions, a floc may be formed by gentle agitation of the waste after the chemical is added. The procedure described above also applies when chemical flocculation is used. When using chemical flocculation, care should be exercised not to break up the floc particles in handling the flocculated waste.

   Because of the peculiarities of some floc formations, they will break up readily upon any excessive agitation after being formed. This is most readily noticed when a liquid with a preformed floc is transferred from the cylinder used in the jar mixing test to the cylinder used in the flocculation test. If the floc does break up and does not re-form immediately, it is suggested that the transfer to the flotation cell not be made and that flotation be accomplished in the vessel where the floc was formed. The procedure for running this test are the same. However, withdrawing of the clarified liquid, as described in step "8", will probably be through a siphon.

Figure III-12. Laboratory bench scale test to simulate air flotation process.—*Continued*

In flotation of a particular waste, it is quite possible that the test using the recirculation ratio of 0.33/1 may not yield the best results. It may be that some other recirculation ratio would yield the results needed to work in with the economy of a final plant design and effluent requirements. Therefore, the tests described above may be repeated with other recirculation ratios until the optimum ratio is obtained. In these tests the values shown in steps "1" and "6" will be changed accordingly.

When running flotation tests in the Rex Float-Treat demonstration kit, the observed rate of rise of the major portion of the solid material should be recorded. This value can be recorded in terms of inches per minute and will be used in determining the full scale plant requirements.

In order to insure the validity of results obtained, care should be taken that representative samples of waste are obtained before running tests. When results have been obtained, they should be recorded on Questionnaire for Design Data Sheets 315-10.101 and 315-10.102. These completed sheets should be returned to CHAIN Belt Company.

Figure III-12. Laboratory bench scale test to simulate air flotation process.—*Concluded*

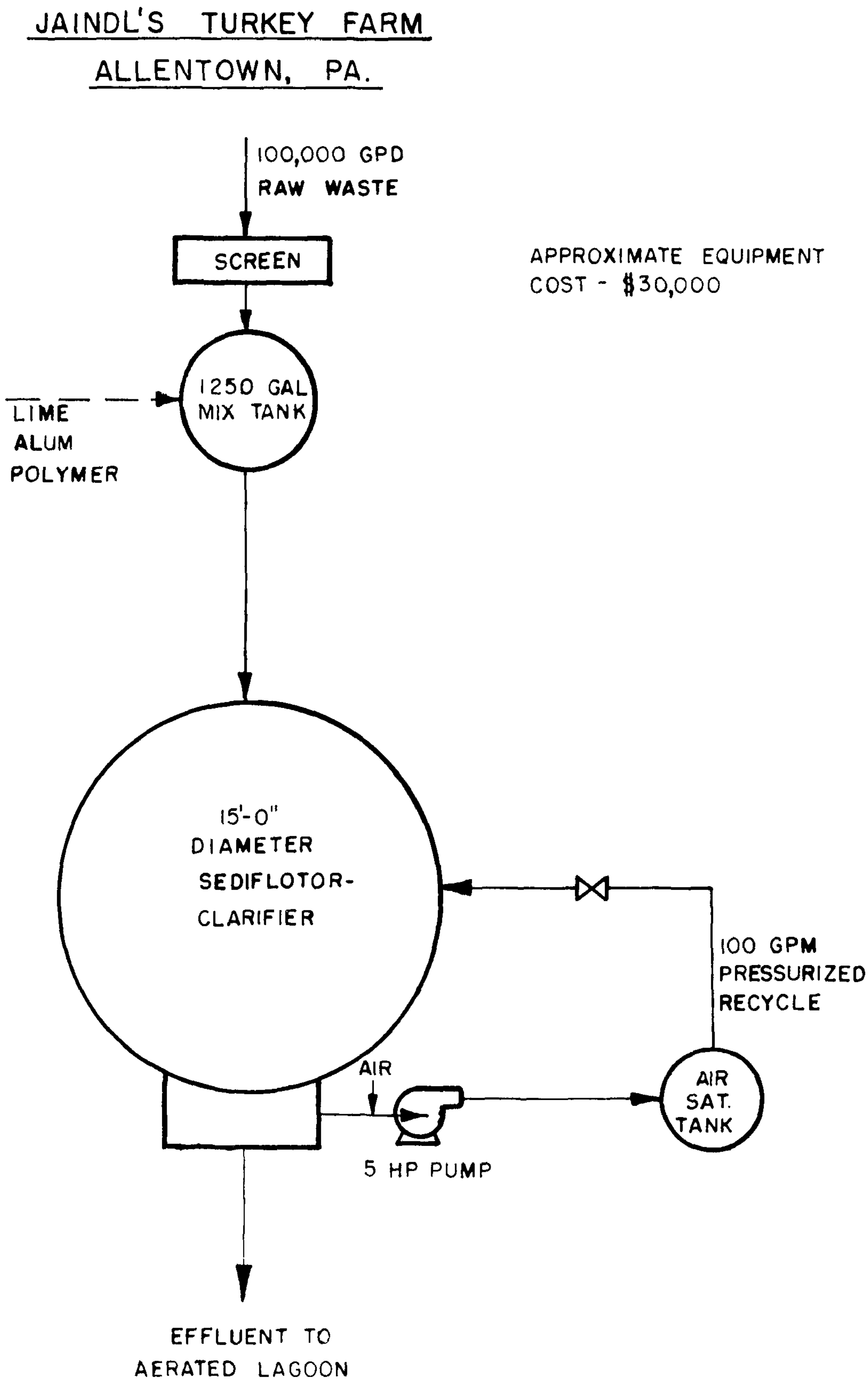


Figure III-13. Poultry-plant pretreatment system at Allentown, Pa., using circular flotation tank.

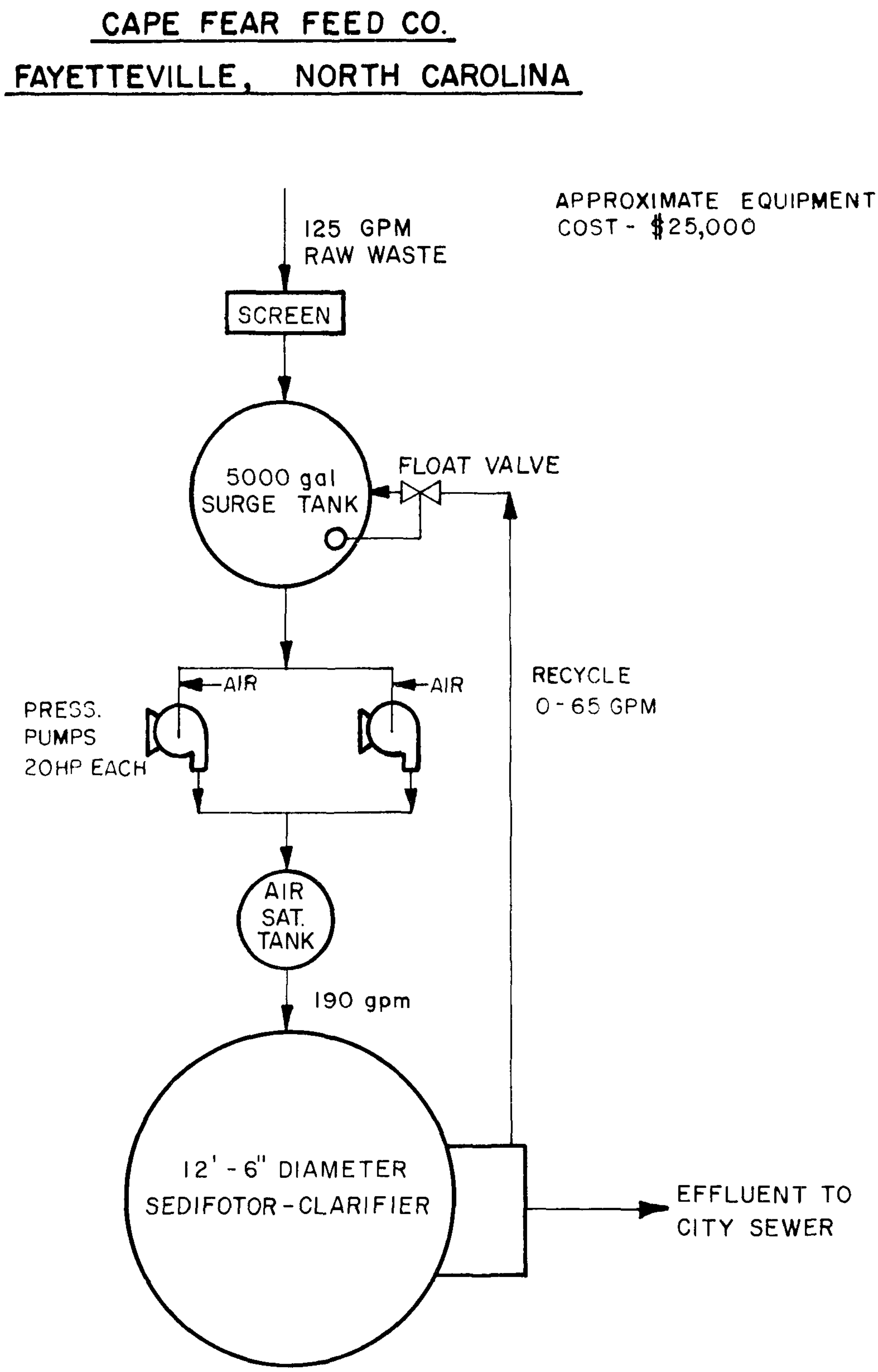


Figure III-14. Poultry-plant pretreatment system at Fayetteville, N.C., using total pressurization with recycle from effluent to influent.

Part IV

MUNICIPAL ORDINANCES

LIMITATIONS ON QUALITY OF POULTRY PLANT WASTEWATER

Limitations of Two Types

Prohibition of Objectionable Matter. Various minerals, toxic materials, and waste characteristics and materials that are difficult to treat are excluded. The following examples are typical.

The Metropolitan Sanitary District of Greater Chicago includes the following exclusions on ingredients that may affect poultry plant effluents:

- Noxious or malodorous liquids, gases, or substances which either singly or by interaction with other wastes are sufficient to create a public nuisance or hazard to life or are sufficient to prevent entry into the sewers for their maintenance and repair

- Solid or viscous wastes which cause obstruction to the flow in sewers or other interference with the proper operation of the sewerage system or sewage-treatment works, such as grease, uncomminuted garbage, animal guts or tissues, paunch manure, bone, hair, hides, fleshings, entrails, and feathers

- Waters or waste containing substances which are not amenable to treatment or reduction by the sewage-treatment process employed or are amenable to treatment only to such degree that the sewage-treatment-plant effluent cannot meet the requirements of other agencies having jurisdiction over discharge to the receiving waters

- Excessive discoloration

Other cities use similar limiting clauses in their ordinances, often copied from the manual [9], from which the Chicago wording was adapted in part.

Concentration of Pollutional Characteristics. The ordinance of the Metropolitan Sanitary District of Greater Chicago provides no top limits for BOD or suspended solids but does include "surcharges" for these items (see "Surcharges," below). It does, however, limit temperature to a maximum of 150° F (65° C) and fats, oils, or greases (hexane solubles) to a maximum of 100 mg/l. These limits are frequently included in municipal ordinances.

A small suburb of Louisville limits BOD to 300 mg/l and suspended solids to 350 mg/l. Its ordinances state: "The Town Board of Trustees is authorized to prohibit the dumping of wastes into the Town's sewage system which, in its discretion, are deemed harmful to the operation of the sewage works of said Town."

Source Information on "Limitations"

A large number of cities use, as a guide, the so-called Model Ordinance published as part of *Water Pollution Control Federation Manual of Practice No. 3* [9]. Article V of the Model Ordinance contains an extensive list of limiting characteristics applicable to poultry plant wastewaters discharged to public sewers. The background material, along with Article V, are too voluminous to reproduce here. The "Regulation of Sewer Use" (Manual of Practice No. 3) is available at $1.50 ($1 to Federation members) from: Water Pollution Control Federation, 3900 Wisconsin Ave., Washington, D.C. 20016. A 15-percent quantity discount is available in lots of 12 or more copies.

SURCHARGES

The Metropolitan Sanitary District of Greater Chicago charges 2.1 cents per 1,000 gallons, 1.4 cents per pound of BOD, and 2.4 cents per pound of suspended solids, after deducting the first 10,000 gallons per day and the BOD and suspended solids it would contain. Also deducted are the sewer district tax (a property-type tax) plus 4 mills per day per employee, an allowance for sanitary sewage discharged during the working day.

Most of the simpler sewage billing systems are based on the water use, ranging from about 50 percent to as high as 125 percent of the water billing, with maximums for BOD, suspended solids, grease, and sometimes other ingredients. These are basic sewer charges applicable to all users—domestic, commercial, and industrial—and are not classified as surcharges unless they include escalation for BOD, suspended solids, grease, etc., and possibly flows, in excess of a "domestic" base. Thus the surcharge portion of the ordinance might be similar in structure to the Chicago ordinance, but with a charge for flow in *excess* of a base, and a charge per pound of ingredients *above* a base represented by discharge from a single residence.

As a guide to municipalities developing charges to industrial users, the Environmental Protection Agency has published *Federal Guidelines—Equitable Recovery of Industrial Waste Treatment Costs in Municipal Systems* [13], from which the following is excerpted:

Quantity or quality formulas based on total cost or average unit costs: This method of cost allocation or derivation of industrial charge is computed by several forms of the generalized formula:

$$C_i = v_o V_i + b_o B_i + s_o S_i$$

where C_i = charge to industrial users, dollars per year

v_o = average unit cost of transport and treatment chargeable to volume, dollars per gallon

b_o = average unit cost of treatment chargeable to BOD, dollars per pound

s_o = average unit cost of treatment (including sludge treatment) chargeable to suspended solids, dollars per pound

V_i = volume of wastewater from industrial users, gallons per year

B_i = weight of BOD from industrial users, pounds per year

S_i = weight of suspended solids from industrial users, pounds per year

Note: The principle applies equally well with additional terms (e.g., chlorine feed rates) or fewer terms (e.g., $v_o V_i$ only).

The terms b_o and s_o may include charges (surcharges) for concentrated wastes above an established minimum based on normal load criteria.

Inasmuch as it is an objective of the Guidelines to encourage the initiation and use of user charges, this general method of allocation is both preferable and acceptable.

Part V

SUMMARY

Pretreatment of poultry-processing wastewater, prior to discharge to a municipal system, is a consideration:

- When constituents prohibited by municipal regulations are present in the wastewater. Feathers, whole blood, and entrails are typical of such prohibited materials.
- When maximum concentrations have been established for certain constituents and the wastewater contains such constituents in excess of those limits. BOD, grease and oils, and suspended solids are examples of such constituents.
- When the poultry processor is paying or anticipates paying for municipal treatment through a surcharge system and can effect economies by pretreatment. Examples of constituents for which surcharge rates may be established are BOD, suspended solids, and possibly grease and oils.

Decisions regarding the last item are the most difficult. To save surcharge dollars by pretreatment, the poultry-plant operator must determine the degree of pretreatment that represents the economic breakpoint. He must also weigh other factors such as the probability that the surcharge rates may change, that the municipal treatment plant may need expansion in the near future and may seek a Federal grant which will introduce requirements previously discussed, and that the State may establish regulations both as to degree of pretreatment and to operation of the facilities (such a law was recently passed in New Jersey). The processor must also consider his own future business plans, such as changes in processing, additional processing, overall expansion, or possibly reduction in operations.

Considering these often elusive variables, the poultry processor must select the type of pretreatment, such as:

- No pretreatment at all
- Secondary screening only
- Secondary screening and separation of floatable and settleable solids by gravity, pressurized air flotation, or other means
- Separation of floatable and settleable solids, as above, but without secondary screening
- Secondary screening and separation of floatable and settleable solids, plus biological or chemical treatment for further BOD removal

The pretreatment processes and the capacities selected depend upon the size of the processing plant, efficiency of the selected process, facilities for handling the materials removed from the wastewater, and related engineering and cost factors, as well as the three regulatory considerations set forth above.

BIBLIOGRAPHY

1. W. M. Crosswhite, R. E. Carawan, and J. A. Macon, "Water and Waste Management in Poultry Processing," *Proceedings, Second Food Wastes Symposium* (Continuing Education Publications, Waldo Hall 100, Corvallis, Oreg. 97331, pp. 323-335, Mar. 1971.
2. W. J. Camp, "Waste Treatment and Control at Live Oak Poultry Processing Plant," *Proceedings 18th Southern Water Resources and Pollution Control Conference*, North Carolina State University, Raleigh, N.C., Apr. 1969.
3. "Wastes from the Poultry Processing Industry," *Technical Report T. R.* W62-3, U.S. Department of Health, Education, and Welfare, Public Health Service, R. A. Taft Sanitary Engineering Center, 1962.
4. "Industrial Waste Profile No. 8, Meat Products," *The Cost of Clean Water Series*, U.S. Department of the Interior, Washington, D.C., 1967.
5. "Waste Treatment Lagoons—State of the Art," *Water Pollution Control Research Series*, 17090 EHXO 7 U.S. Environmental Protection Agency, Washington, D.C., July 1971.
6. Chas. T. Decker, "Rate Surcharges: Friend or Foe?" *Water and Wastes Engineering 8*(11), F2-F4, Nov. 1971.
7. Y. Maystre and J. C. Geyer, "Charges for Treating Industrial Wastewater in Municipal Plants," *Journal of the Water Pollution Control Federation, 42*(7), 1277-1291, July 1970.
8. "The Poultry Processing Industry—A Study of the Impact of Water Pollution Control Costs," U.S. Department of Agriculture Economic Research Service, Marketing Research Report No. 965, Prepared for Office of Water Programs, Environmental Protection Agency, June 1972.
9. "Regulation of Sewer Use," *Water Pollution Control Federation Manual of Practice No. 3*, Washington, D.C., 1963.
10. John M. Bolton, "Wastes From Poultry Processing Plants," *Proceedings of the 13th Industrial Waste Conference*, Purdue University, Lafayette, Ind., May 1958.
11. Nelson Leonard Nemerow, *Theories and Practices of Industrial Waste Treatment*, Syracuse, N.Y., Addison-Wesley Publishing Co., Inc., 1963.
12. A. J. Steffen, "The Control and Treatment of Poultry Processing Wastes," Second Annual Meeting of the Mississippi Sewage and Industrial Waste Association, Mar. 1959.
13. *Federal Guidelines—Equitable Recovery of Industrial Waste Treatment Costs in Municipal Systems*, Environmental Protection Agency, Washington, D.C., Oct. 1971.

Appendix A
LIST OF EQUIPMENT MANUFACTURERS

Following is a list of manufacturers of equipment discussed in this study. Any mention of products or services here or elsewhere in the study is for information only, is not selective unless it is used to illustrate a point, and is not to be construed as an endorsement of the product or service by the Environmental Protection Agency or the authors.

Although the list is intended to be complete, there may be some oversights. Such oversights are not to be construed as reflecting on the merits of the product or service.

The authors will appreciate being advised of errata, in order to improve subsequent editions of this list.

Rotating Biological Contactor:

Bio-Surf . . . . Autotrol Corporation, Bio Systems Division
5855 North Glen Park Road
Milwaukee, Wis. 53209

Hormel Rotating Disc . . . . G. A. Hormel & Co.
Environmental Pollution Control Division
Austin, Minn. 55912

Vibrating Screens:

"Selectro," "Gyroset," "Kelly" . . . . . Productive Equipment Corporation
2924 W. Lake Street
Chicago, Ill. 60612

Other models . . . . Allis-Chalmers Manufacturing Company
1126 S. 70th Street
Milwaukee, Wis. 53214

DeLaval Separator Company
Poughkeepsie, N.Y. 12600

Link Belt, Materials Handling Division
FMC Corporation
300 Pershing Road
Chicago, Ill. 60609

Rex Chainbelt, Inc., Environmental Control Group
1901 S. Prairie
Waukesha, Wis. 53186

Simplicity Engineering Company
Durand, Mich. 48429

Static Screens (Wedge Bar):

Static Sieves . . . . F. J. Clawson & Associates, Inc.
6956 Highway 100
Nashville, Tenn. 37205

Bauer Hydrasieve . . . . Bauer Bros. Company
Subsidiary of Combustion Engineering, Inc.
P.O. Box 968
Springfield, Ohio 45501

Static Screens (Wedge Bar)—Continued:	
Wedge-shaped screen with bars in direction of flow	Hendricks Manufacturing Company Carbondale, Pa. 18407
Other models	Dorr-Oliver, Inc. Havemeyer Lane Stamford, Conn. 06904 Hydrocyclonics Corporation 968 North Shore Drive Lake Bluff, Ill. 60044 Peabody Welles Roscoe, Ill. 61073
Enclosed Vacuum Tanks: Vacuator	Dorr-Oliver, Inc. Havemeyer Lane Stamford, Conn. 06904
Rotary Barrel Screens:	
North Green Bay Screen	Green Bay Foundry and Machine Works Box 2328 Green Bay, Wis. 54306
Other models	Dorr-Oliver, Inc. Havemeyer Lane Stamford, Conn. 06904 Link Belt Material Handling Division FMC Corporation 300 Pershing Road Chicago, Ill. 60609 Rex Chainbelt, Inc., Environmental Control Group 1901 S. Prairie Waukesha, Wis. 53186
Rotating Disk Screens	Link Belt Rex Chainbelt
Eccentric-Weighted Horizontal Disk Screens:	
Aero Vibe	Allis Chalmers
Syncro-Matic	Eriez Syncro-Matic 1401 Magnet Drive Erie, Pa. 16512
Sweco	Sweco, Inc. 6033 E. Bandine Boulevard Los Angeles, Calif. 90054
Other models	DeLaval Separator Company Poughkeepsie, N.Y. 12600 Hydrocyclonics Corporation 968 North Shore Drive Lake Bluff, Ill. 60044 Kason Corporation 231 Johnson Avenue Newark, N.J. 07108
Gravity Grease Recovery and Separation:	
Infilco	Infilco Division, Westinghouse Electric Company 901 S. Campbell Street Tucson, Ariz. 85719
Hardinge	Koppers Co., Metal Products Division Hardinge Operation York, Pa. 17405

Gravity Grease Recovery and Separation—Continued:

Other models. . . . . Chicago Pump Division, FMC Corporation
622 Diversey Parkway
Chicago, Ill. 60614

Clow Corporation, Waste Treatment Division
1999 N. Ruby Street
Melrose Park, Ill. 60160

Crane Company, Environmental Systems Division
Box 191
King of Prussia, Pa. 19406

Dorr-Oliver, Inc.
Havemeyer Lane
Stamford, Conn. 06904

Dravo Corporation
One Oliver Plaza
Pittsburgh, Pa. 15222

Environmental Services, Inc.
1319 Mt. Rose Avenue
York, Pa. 17403

Envirotech Corporation
Municipal Equipment Division
100 Valley Drive
Brisbane, Calif. 95005

Graver, Division of Ecodyne Corporation
U.S. Highway 22
Union, N.J. 07083

Jeffrey Manufacturing Company
961 N. Fourth Street
Columbus, Ohio 43216

Keene Corporation, Fluid Handling Division
Cookeville, Tenn. 38501

Lakeside Equipment Company
1022 E. Devon Avenue
Bartlett, Ill. 60103

Link Belt Environmental Equipment
FMC Corporation
Prudential Plaza
Chicago, Ill. 60601

Ralph B. Carter Company
192 Atlantic Street
Hackensack, N.J. 07601

Rex Chainbelt, Inc., Environmental Control Group
1901 S. Prairie
Waukesha, Wis. 53186

Walker Process Equipment, Inc.
Division of Chicago Bridge & Iron Company
Box 266
Aurora, Ill. 60507

Zurn Industries, Inc.
1422 East Avenue
Erie, Pa. 16503

Dissolved Air Flotation:

Graver "Aeroflotor"	Graver, Division of Ecodyne Corporation U.S. Highway 22 Union, N.J. 07083
Other models	Beloit-Passavant Corporation Middletown, Ohio 45042 Black Clawson Company Middletown, Ohio 45042 The Carborundum Co.—"Pacific" Buffalo Avenue Niagara Falls, N.Y. 14302 Environmental Systems Division of Litton Industries, Inc. 354 Dawson Drive Camarillo, Calif. 93010 Envirotech Corporation Municipal Equipment Division 100 Valley Drive Brisbane, Calif. 95005 Infilco Division, Westinghouse Electric Company 901 S. Campbell Street Tucson, Ariz. 85719 Keene Corporation, Fluid Handling Division Cookeville, Tenn. 38501 Komline-Sanderson Engineering Corporation Peapack, N.J. 07977 Rex Chainbelt

U.S. ENVIRONMENTAL PROTECTION AGENCY • TECHNOLOGY TRANSFER