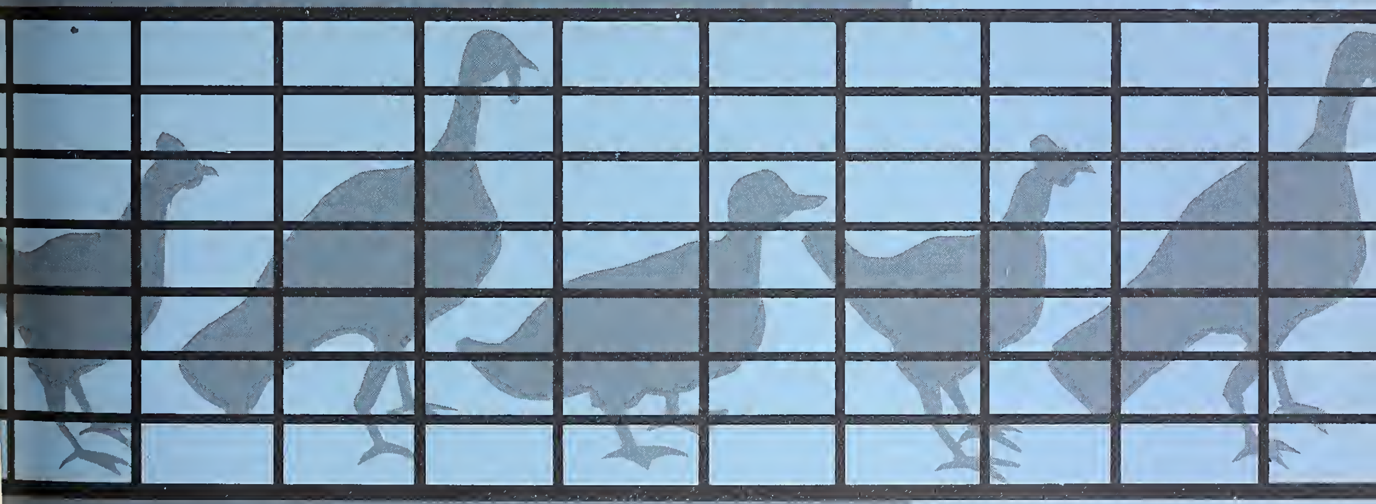
Processing POULTRY BYPRODUCTS in Poultry Slaughtering Plants

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service
Marketing Research Division



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HOW TO USE THIS REPORT

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Widespread interest in the possibility for profitable utilization of by-products from poultry slaughtering plants prompted this study. A preceding study indicated that less than half of the poultry slaughtering plants in the United States receive any net income from inedible byproducts.[1/] Many plants incur net expenses in disposal of these byproducts - offal, feathers, blood, and manure.

The principal outlets of the slaughtering plants for inedible byproducts are renderers. Prices paid by renderers, however, often were low and the collection service provided frequently was unsatisfactory. Quite logically the question of alternatives arose. That is, how could poultry plants obtain more net income from byproducts in terms of both prices and services? Could a poultry slaughtering plant afford to own and operate its own facilities for processing inedible byproducts as an integral part of the slaughtering operation? If yes, under what conditions? These are the principal questions answered in considerable detail in this report. Detailed economic-engineering estimates are given for rendering facilities of six different sizes. These estimates cover both investment and operating costs along with details on the physical items (land, buildings, equipment, labor, and fuel) covered. Additional details are provided in the appendixes to the report.

The study of rendering processes for the conversion of poultry wastes into byproducts suitable for animal feeds has resulted in the following general conclusions concerning the feasibility of rendering plants integrated with slaughtering operations.

1/ Utilization and Disposal of Poultry Byproducts and Wastes, Mktg. Res. Rpt. No. 143, U.S. Dept. Agr., Washington, D. C., Nov. 1956.

1. Volume is the key to a profitable rendering operation. Lowest costs are obtained when each piece of equipment is used to capacity and when equipment of large capacity can be utilized. This principle is illustrated in figure A. Production costs for the small (D) plant decline sharply as production approaches design capacity. A similar relationship exists for the larger plant (F) but the possible range in costs is much wider.

2. The type of process to be used should depend upon available markets for the raw material as well as the finished product. Because of higher costs, a favorable market is especially important for the smaller plant. Fortunately, a small plant may sometimes find itself in a deficit area where prices are on a New York or Chicago plus freight basis. Figure B illustrates the relationship which might be expected. The assumed price of 1.10 per unit of protein is used in the reports to assure comparability between processes described. Local prices should be carefully checked.

The primary purpose of the report is to provide poultry plant managers and other interested persons basic guides in making decisions on this method of attempting to secure income from poultry byproducts. Plant managers are provided enough detail so that appropriate estimates of costs can be made, preferably with the aid of competent engineering specialists. The potential income from an integrated rendering operation can then be compared to the income which might be derived from the sale of the raw byproducts and a decision can be made regarding the feasibility of the rendering operation.

The data shown are to serve as a basis for computing estimates which will be appropriate for a specific plant. Notice the table on estimated fixed capital for Plant E. An allowance of $21,800 is included for land, building and well cost. With an estimated yearly cost of 16% for maintenance, depreciation, taxes, and insurance, this capital investment could add up to $3,488 per year. Any savings in capital through the utilization of existing land, buildings or wells would reduce costs of production. In a similar way one should consider whether 50% of labor costs is appropriate as a charge for supervision and whether 25% of the estimated manufacturing cost is appropriate as a charge for general expense of manufacturing with the accounting procedure he uses. While these ratios are appropriate for most businesses they need not be extended to the rendering operation so long as it is considered a salvage operation.

Many other differences between the conditions confronting a particular poultry plant and those given in this report are possible. For example, labor rates might be higher or lower than the $2 per hour used; fuel and electric costs might be higher or lower; or tax and insurance rates might

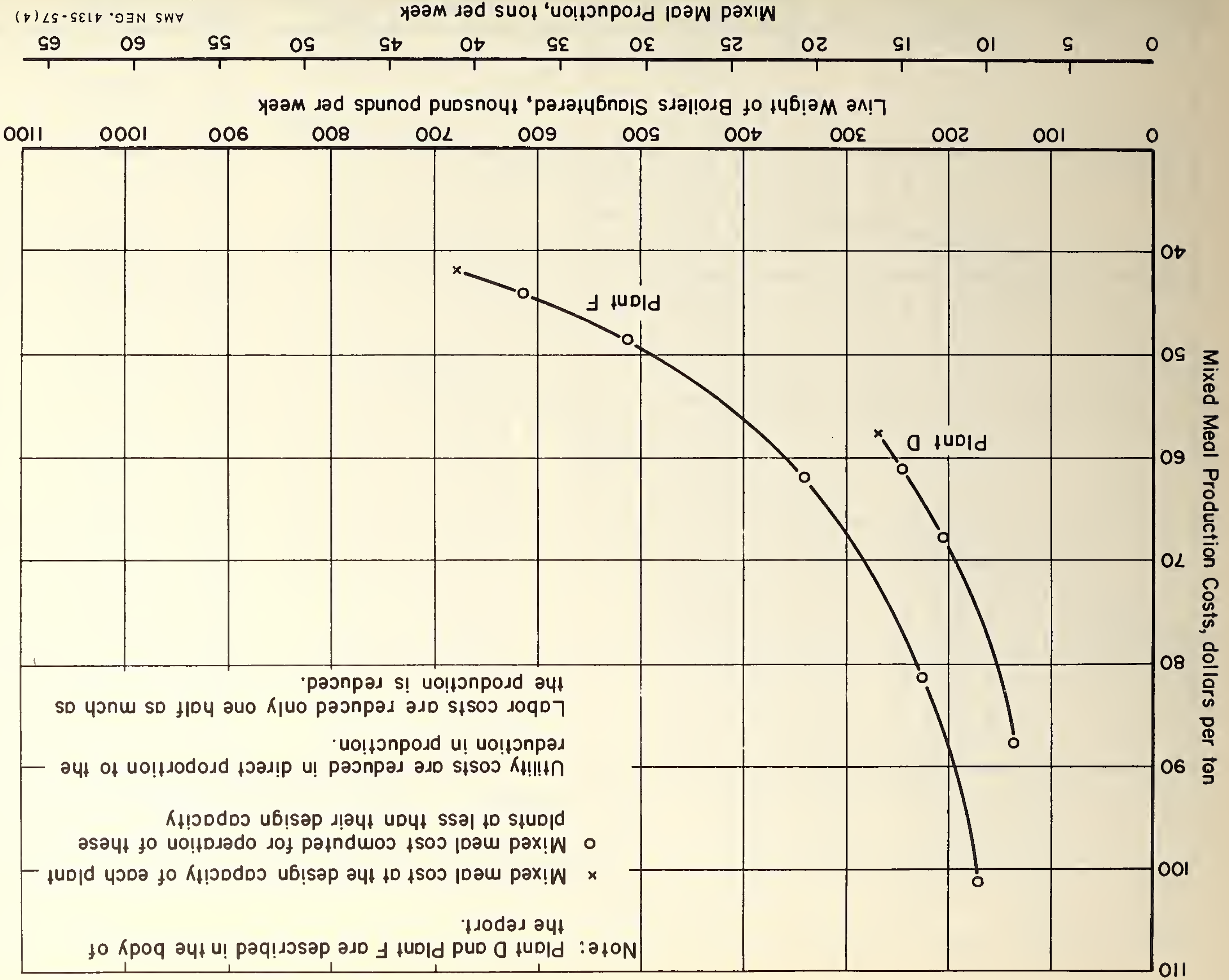
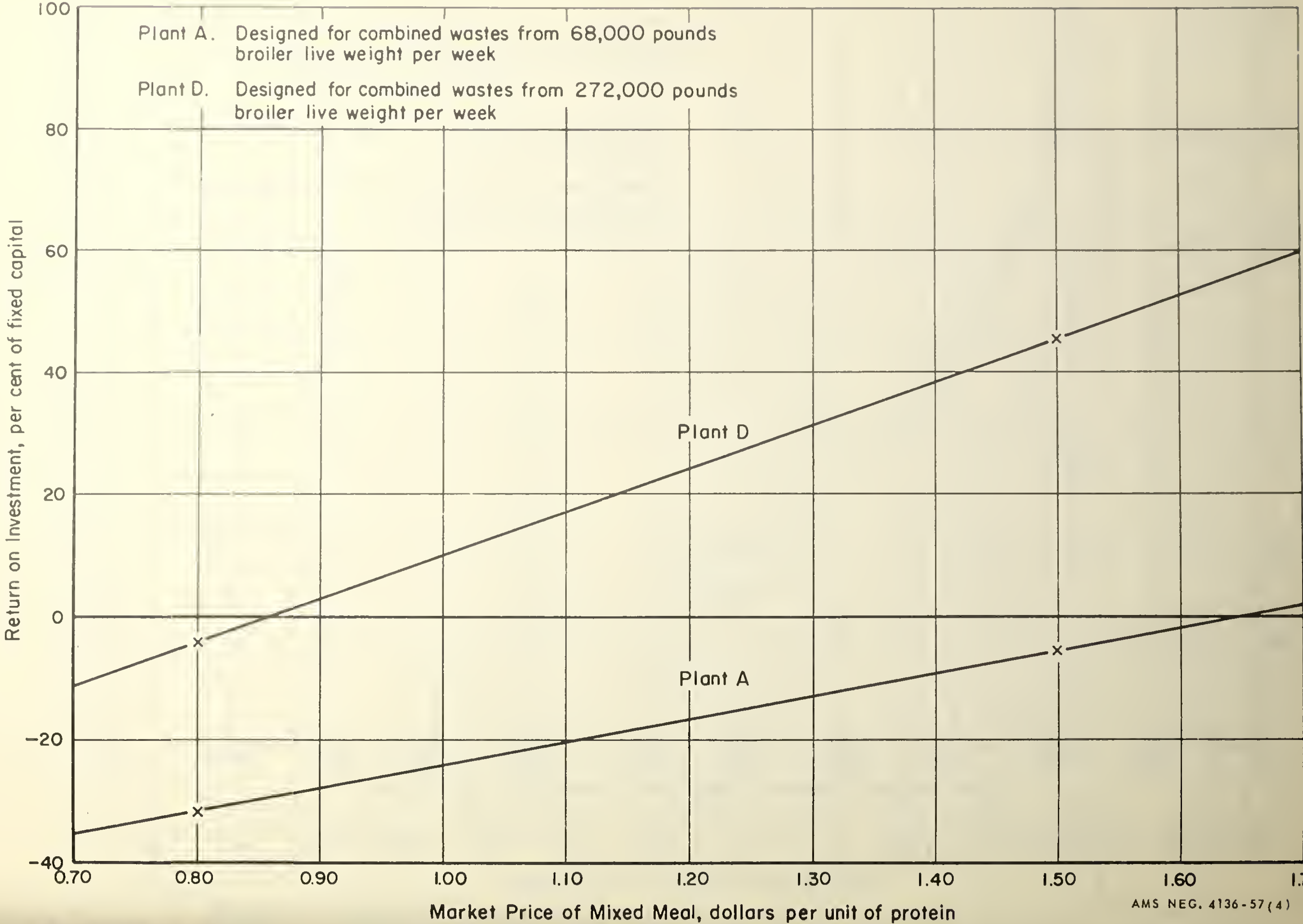


Figure A. --Estimated variation in mixed meal production cost with production level

Figure B. --Illustration of variation in estimated return on investment (before Federal income taxes) with product market price



differ. Other differences might result if the poultry plant already has a boiler of sufficient size to handle the steam requirements of the byproducts facility in addition to the slaughtering plant or when not being used in the slaughtering plant. Used equipment might be purchased.

In other words the report provides in considerable detail guideposts by which individual plants can make decisions on a question that many have considered. It also gives some clues as to the reasonableness of the prices, if any, being paid by renderers for inedible byproducts. Still further, the report provides a basis for poultry plants to estimate the probable costs and returns of a rendering facility so designed and located as to serve a group of plants together.

This report does not answer several important questions. Feed control regulations, particularly of the States, impose varying requirements on the purity and acceptability of feeds made by cooking offal or hydrolizing feathers. Feed manufacturers also impose certain quality requirements on the materials which they purchase or are willing to purchase. Some of the processes, particularly relating to the conversion of feathers, are patented. Feed control regulations, feed manufacturers' specifications, and patents should all be consulted and considered as part of the evaluation of processing and marketing by any plant.

Another important problem is the type of disposal method or facility, if any, most economical for the comparatively small slaughtering plants. Although several suggestions were made on this problem in the earlier study referred to above, further research is needed to develop inexpensive methods of storage or transport so that small quantities can be salvaged. Information is also needed on specific outlets for rendered materials, i.e., names and addresses of buyers so that specific estimates of income for a given locality can be prepared. Market development work is needed to exploit the sales of mixed meal.

The sale of commercial feedingstuffs is regulated by various State and Federal laws which are designed to prevent misleading brand names, incorrect labeling with regard to ingredients, adulteration of ingredients, or the use of injurious ingredients. In order to facilitate an accurate description of ingredients, the following definitions have been adopted by the Association of American Feed Control Officials:

Blood Meal is ground dried blood. (Adopted 1926.)

Poultry Byproduct Meal consists of the ground, dry-rendered clean, wholesome parts of the carcass of slaughtered poultry, such as head, feet, undeveloped eggs, gizzard, and intestines, exclusive of feathers and gizzard and intestinal contents, except in such trace amounts as might occur unavoidably in good factory practice. (Adopted 1954.)

A tentative definition of hydrolyzed poultry feathers is this: The product resulting from the treatment under pressure of clean, undecomposed feathers from slaughtered poultry, free of additives, and/or accelerators. Not less than 70 percent of its crude protein content shall consist of "digestible protein." (Proposed 1955.) NOTE -- The method of Almquist and associates, Journal of Nutrition, Volume 10. No. 2, August 10, 1935 may be used to determine its digestibility.

To date there is no definition covering a mixture of dried blood, offal, and feathers. For this reason, a product of this type must be labeled in such a way as to indicate clearly the ingredients used. (Application for registration of specific feeding stuffs should be made to the appropriate State feed control official.) The amount of feather meal must be clearly indicated, as many States regulate the amount of feather meal permitted in feeds.

Unless the label so indicates, the addition of blood to poultry byproduct meal or the addition of feather meal to poultry byproduct meal or meat scrap is considered as an introduction of an adulterant and is not permitted. In a similar way, the use of lime in the production of feather meal would require special labeling.

The following report covers a study of Processing Poultry Byproducts in Poultry Slaughtering Plants, conducted under a research contract with the USDA by the Battelle Memorial Institute. The contract was supervised by the writer of this introductory section.

PROCESSING POULTRY BYPRODUCTS

in

POULTRY SLAUGHTERING PLANTS

by

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and R. B. Filbert, Jr.

INTRODUCTION

The U. S. Department of Agriculture has recognized the problem poultry slaughterers face in trying to dispose of their slaughtering wastes profitably and has also recognized the need for engineering data to define the technical and economic limits which poultry slaughterers would face in converting their wastes into marketable by-products. To obtain the needed information, the Department made a contract with the Battelle Memorial Institute, a research organization, for a technical and economic study of poultry waste rendering processes. The contract was administered by the Marketing Research Division of the Agricultural Marketing Service.

This report, prepared by technicians of the Institute, presents the results of the study. It is hoped that the data presented in the report will help poultry slaughterers decide how they can dispose of their waste products most economically.

SUMMARY

A study of rendering processes for the conversion of poultry wastes into by-products suitable for animal feeds has been conducted by collecting and analyzing information on poultry wastes and by-product yields and by studying current rendering practice as it applies to processing poultry wastes. This study has resulted in the following general conclusions concerning the feasibility of rendering plants integrated with slaughtering operations*:

*The term "integrated", throughout this report, refers to a rendering plant, with its own auxiliary facilities, whose capacity is geared to the slaughtering plant (or plants) that it serves. It has further been assumed that this rendering plant would be close enough to the slaughtering plant (or plants) it serves that waste transportation charges would be negligible. Available data did not permit an estimate of savings possible through the use of utilities (water, steam, electricity) common to both the rendering and slaughtering operations. However, it is believed that these savings would be relatively small in most cases, compared to the total cost of operation.

(1) At slaughtering volumes under 100, 000 pounds of live weight per week, the losses involved in operating a rendering plant would seem to exceed the costs presently incurred by a slaughterer in merely getting rid of his wastes by any other method.

(2) At slaughtering volumes between 100, 000 and 300, 000 pounds of live weight per week, a rendering operation may cost no more (and possibly less) than current disposal procedures.

(3) At slaughtering volumes in excess of 300, 000 pounds of live weight per week, profitable operation of integrated rendering plants appears possible, with returns on investment becoming fairly attractive when the 500, 000 pound mark is passed.

(4) Extraction of fat, or the production of blood meal, appears impractical at slaughtering volumes below approximately one million pounds live weight per week.

(5) Production of mixed meal from the combined wastes from a slaughtering plant appears to be the most attractive procedure – provided that a market exists or can be developed for this material.

(6) The exact solution to the waste problems of slaughterers in a given region will depend on a number of local factors that should be studied in each case before a final decision is made.

(7) Utilization of a dryer in conjunction with cookers rather than cookers alone can be more profitable in the case of producing feather meal.

RENDERING PLANT DATA

Operations

Current rendering practice for poultry wastes comprises the following operations: (1) evaporating the bulk of the water in a dry-rendering cooker, (2) drying to about 8 per cent moisture in either the same cooker or in a separate dryer, (3) pressing this dry material if it contains extractable fat to reduce the fat content to about 10 per cent, and (4) grinding the material to pass through 8- to 12-mesh screens.

Poultry offal (which consists of the viscera, heads, and feet) when processed alone, yields a tankage which normally contains more than 20 per cent fat, and must be pressed before it can be ground. Feather meal and dried blood contain about 1 per cent fat and are not pressed before grinding. Feathers in most plants are processed in a cooker at elevated pressure (1-1/2 to 2 hours' total time in the cooker) to a moisture content of 40 to 50 per cent and then transferred to a separate dryer where the drying is completed. Offal and blood are processed at atmospheric pressure. The offal may be reduced to a moisture content of about 40 per cent and then transferred to a separate dryer. Most plants, however, complete the drying in the cooker. Some rendering plants mix broiler offal, feathers, and blood (if it is received) together before cooking. This mixed material yields a dry product with a fat content of about 10 per cent which does not need to be pressed before grinding. The waste gases from cookers are usually condensed and cooled with cold water in a barometric condenser to reduce the offensive odors coming from the waste gases.

Equipment

The cookers in common use range from a nominal size of 4 x 7 feet (diameter x length) to 5 x 12 feet. The heat necessary for evaporation in the cooker is supplied by steam which condenses in the jacket of the cooker. The cookers are equipped with paddles to agitate the charge while cooking and thus improve heat transfer and prevent burning and caking on the cooker shell.

Both steam-tube dryers and direct-fired dryers are in use in poultry waste rendering plants. The steam-tube dryer has an advantage in that lower temperatures are used throughout the dryer than exist in some areas of the direct-fired dryer, and thus there is less chance for the material to be damaged by overheating. The direct-fired dryer has the advantage of lower initial cost. Both manufacturers and users claim that direct-fired dryers are satisfactory for poultry waste by-products if they are operated properly.

For extraction of fat from tankage, both curb presses (also called cage presses and hydraulic presses) and screw presses are used. The curb press is the older unit and is in more common use in rendering plants processing poultry wastes. The screw press requires less labor and will press out more fat than the curb press. This press must be operated more carefully than the curb press; tramp metal especially must be kept out of the rotating screw section. The press cake is ground in a hammermill. A separate cake crusher may be used when not incorporated in the hammermill, if cakes from a curb press are to be ground.

Yields and Material Balances

Table 1 summarizes the estimated average waste yields and by-product yields for processing broiler wastes. Fowl and turkey waste and by-product yields are reported to vary over a wider range than those for broilers, because these birds vary much more in age, size, and type than do broilers. No attempt has been made to report average yield figures for fowl and turkey, (1) because not enough yield data were obtained for these birds to calculate representative averages and (2) because there were indications that average yield figures for fowl and turkey would be of little value in specific cases, since the birds slaughtered in a particular plant could differ significantly from any calculated averages. A specific example of estimated waste and by-product yields for high-fat-yield fowl is shown in Table 2. Similarly, estimated waste and by-product yields for turkeys weighing approximately 15 pounds are shown in Table 3. Detailed data and discussions will be found in Appendixes A and B.

Material balances and plant flow of material for a mixture of offal, feathers, and blood, and for the separate waste materials are shown in Figures 1, 2, 3, and 4. All data were based on a beginning unit live weight of 100 pounds of broilers. Processing in a cooker only, and in a cooker-dryer combination is illustrated. In the case of offal (Figure 2), fat separation is also illustrated. Three and four significant figures are used in these figures for internal consistency, not as a measure of accuracy of the estimated yields.

Although separate processing of blood is illustrated in Figure 4, it was not considered in the following sections of the report dealing with plant costs and processing costs. Figure 4 shows that 100 pounds of broilers yield approximately 3.5 pounds of raw blood, which is reduced to about 0.8 pound of dried material during processing. At weekly slaughtering rates of 500,000 pounds live weight, one 4 x 7-foot-cooker load per day would be produced. Scheduling of this single load of a different material, however, would add a burden to the operating crew. Furthermore, by the time this much blood had accumulated, much of it would be coagulated, making handling difficult. This one cooker load would yield about 780 pounds of dried blood, worth about $34 if such a small output could be readily marketed. Since the major emphasis in this study is on the processing of wastes from small slaughtering operations (under 500,000 pounds live weight per week in most cases), it was felt that separate processing of blood could be eliminated for estimating purposes without changing the conclusions of the study.

Energy Balances

Information on energy requirements for the rendering of poultry wastes was obtained from renderers, equipment manufacturers, and the literature. The major energy requirement in rendering is for the evaporation of the water contained in the wastes charged to the cookers. Average fuel consumption was estimated to be 25.6 gallons of fuel oil (138,000 Btu per gallon) per ton of water evaporated. At $0.14 per gallon the fuel cost is $3.53 per ton of water evaporated. Electrical energy, used primarily for driving motors, was estimated at 35.3 kwhr per ton of water evaporated, which at a rate of $0.03 per kwhr is equivalent to $1.06 per ton of water evaporated. Cooling water was estimated at 20,000 gallons per ton of water evaporated. At a rate of $0.02 per thousand gallons the cooling water cost is equivalent to $0.40 per ton of water evaporated.

TABLE 1. ESTIMATED AVERAGE BROILER WASTE AND BY-PRODUCT YIELDS

	Pounds Per 100 Pounds of Live Broilers			
	Offal	Blood	Feathers	Mixed
Waste Yield From Poultry	17.5	3.5	7.0	28.0
Water Pick-Up[(a)]	1.0	--	15.0	16.0
Total Waste Yield	18.5	3.5	22.0	44.0
Water Evaporated	12.70	2.72	16.50	31.92
Dry Product (8% Water)	5.80	0.78	5.50	12.08
Pressed Product (10% Fat)	5.16	--	--	--
Fat	0.64	--	--	--

(a) These figures are considered reasonable; actual figures obtained in specific slaughtering plants depend on plant practice.

TABLE 2. ESTIMATED HIGH-FAT-YIELD FOWL WASTES AND BY-PRODUCT YIELDS

	Pounds Per 100 Pounds of Live Fowl			
	Offal	Blood	Feathers	Mixed
Waste Yield From Poultry	17.0	3.0	7.0	(b)
Water Pick-Up[(a)]	1.0	--	13.0	
Total Waste Yield	18.0	3.0	20.0	
Water Evaporated	10.56	2.33	14.50	
Dry Product (8% Water)	7.44	0.67	5.50	
Pressed Product (10% Fat)	4.27	--	--	
Fat	3.17	--	--	

(a) These figures are considered reasonable; actual figures obtained in specific slaughtering plants depend on plant practice.

(b) There is no particular advantage to mixing fowl wastes prior to cooking, since the fat content is still too great to permit grinding without pressing.

TABLE 3. ESTIMATED FIFTEEN-POUND TURKEY WASTES AND BY-PRODUCT YIELDS

	Pounds Per 100 Pounds of Live Turkey			
	Offal	Blood	Feathers	Mixed
Waste Yield From Poultry	12.5	3.5	7.0	23.0
Water Pick-Up[(a)]	--	--	7.0	7.0
Total Waste Yield	12.5	3.5	14.0	30.0
Water Evaporated	7.5	2.72	8.1	18.32
Dry Product (8% Water)	5.0	0.78	5.9	11.68
Pressed Product (10% Fat)	4.17	--	--	--
Fat	0.83	--	--	--

(a) These figures are considered reasonable; actual figures obtained in specific slaughtering plants depend on plant practice.

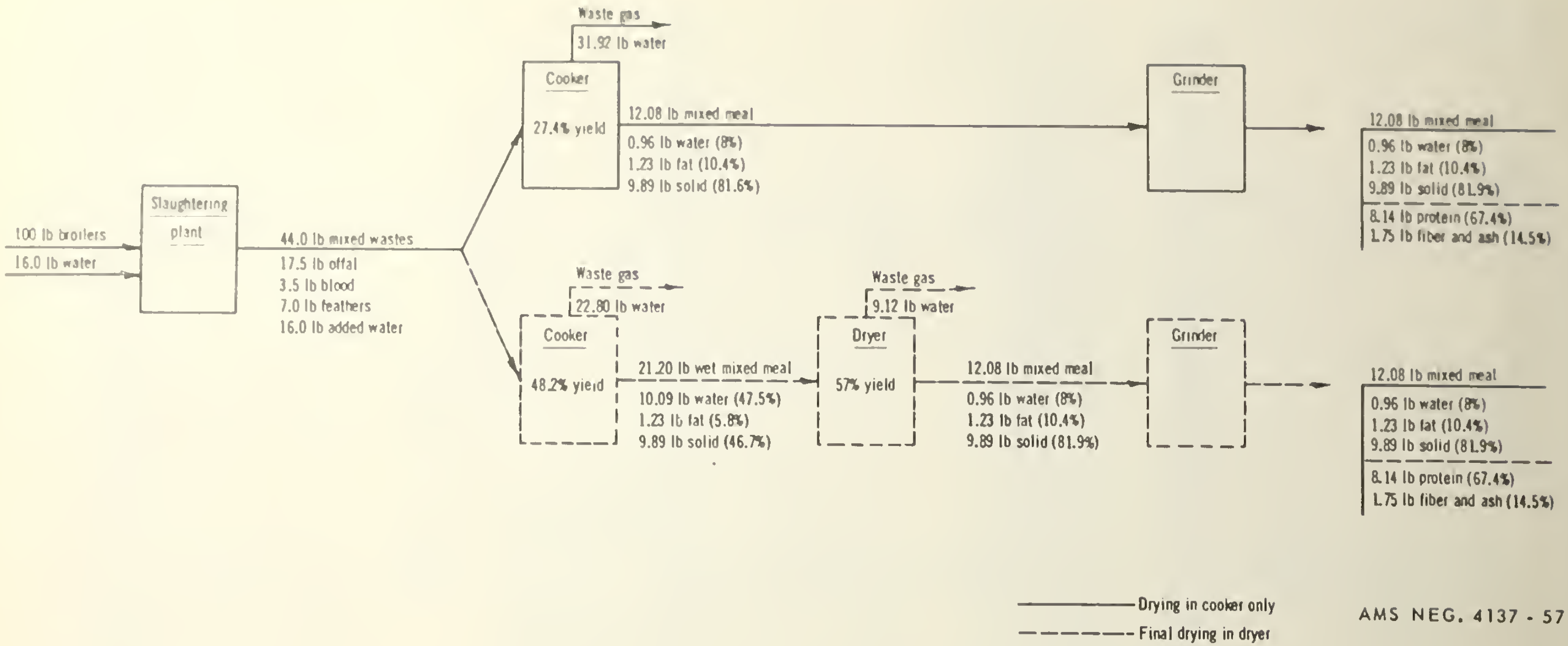

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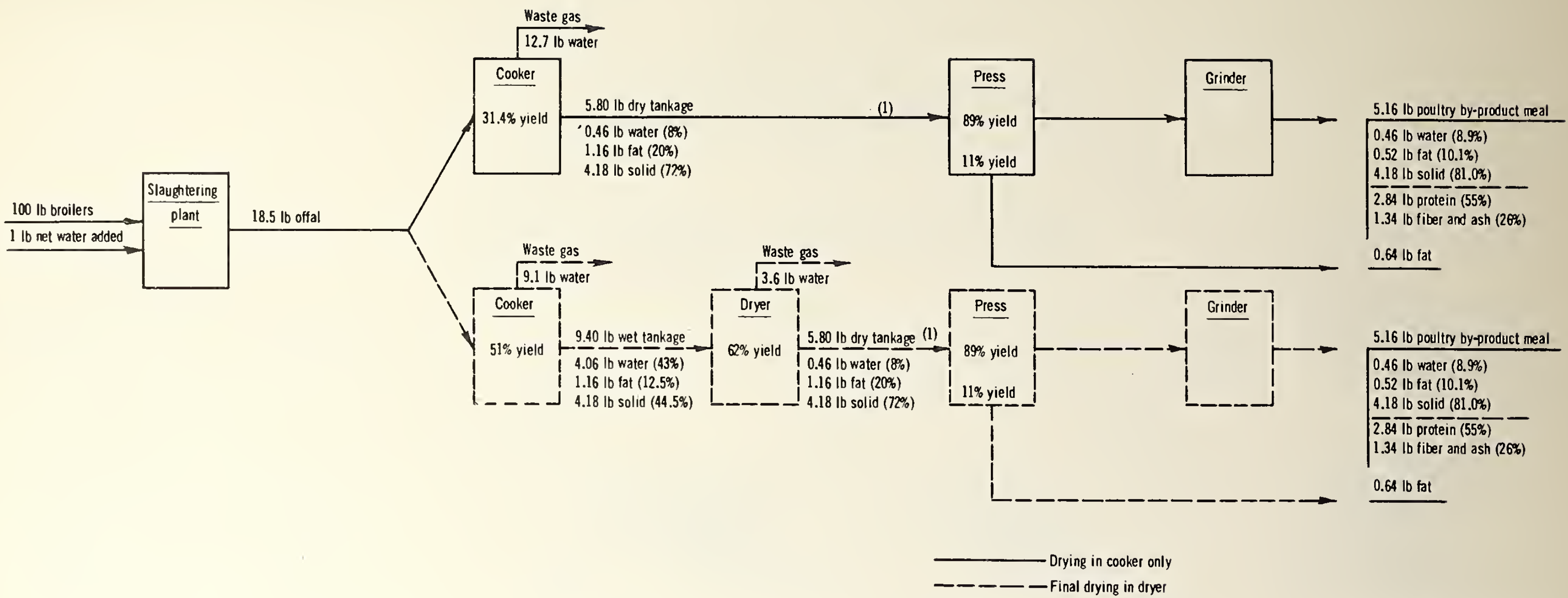
FIGURE 1. BROILER MIXED WASTE PROCESSING

Estimated yields are carried to the second decimal to balance the figures, and do not imply that the estimated yields are that accurate.



(1) Dry tankage from cooker or dryer can be final product sold to another renderer for rest of processing. Average protein content is 49 per cent.

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FIGURE 2. BROILER OFFAL PROCESSING

Estimated yields are carried to the second decimal to balance the figures, and do not imply that the estimated yields are that accurate.

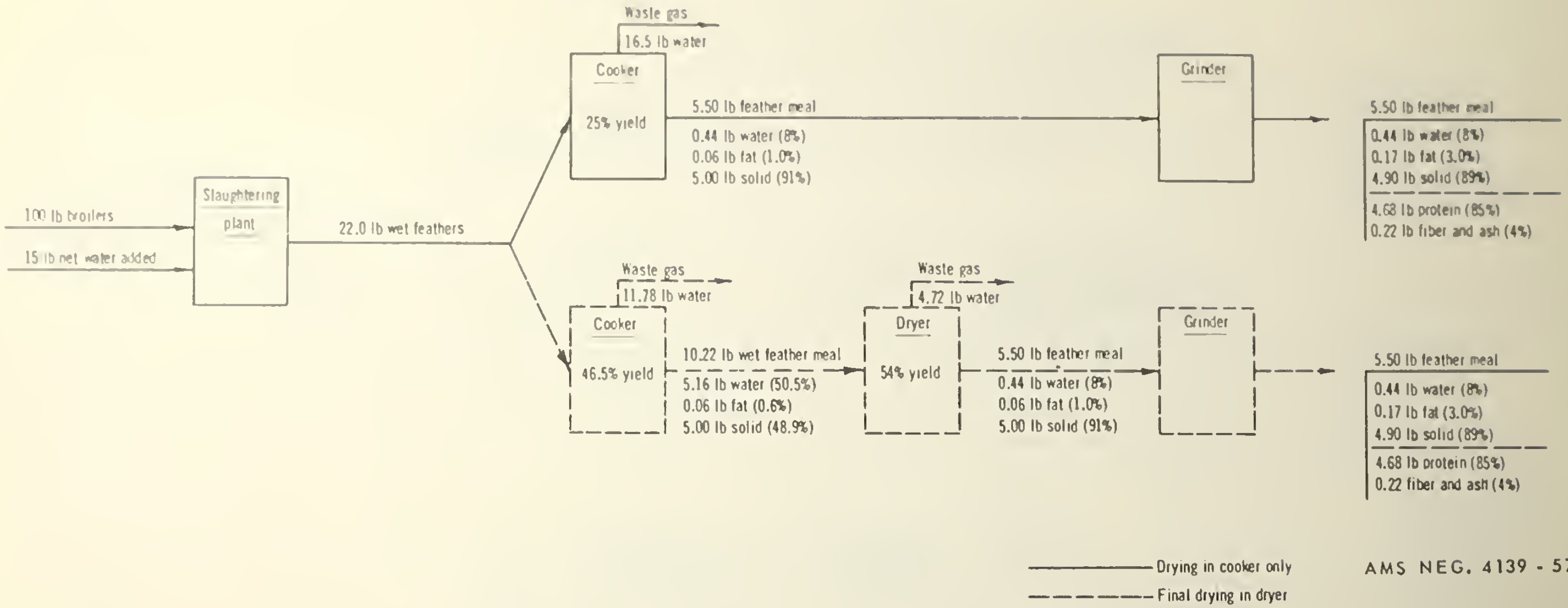

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FIGURE 3. BROILER FEATHER PROCESSING

Estimated yields are carried to the second decimal to balance the figures, and do not imply that the estimated yields are that accurate.

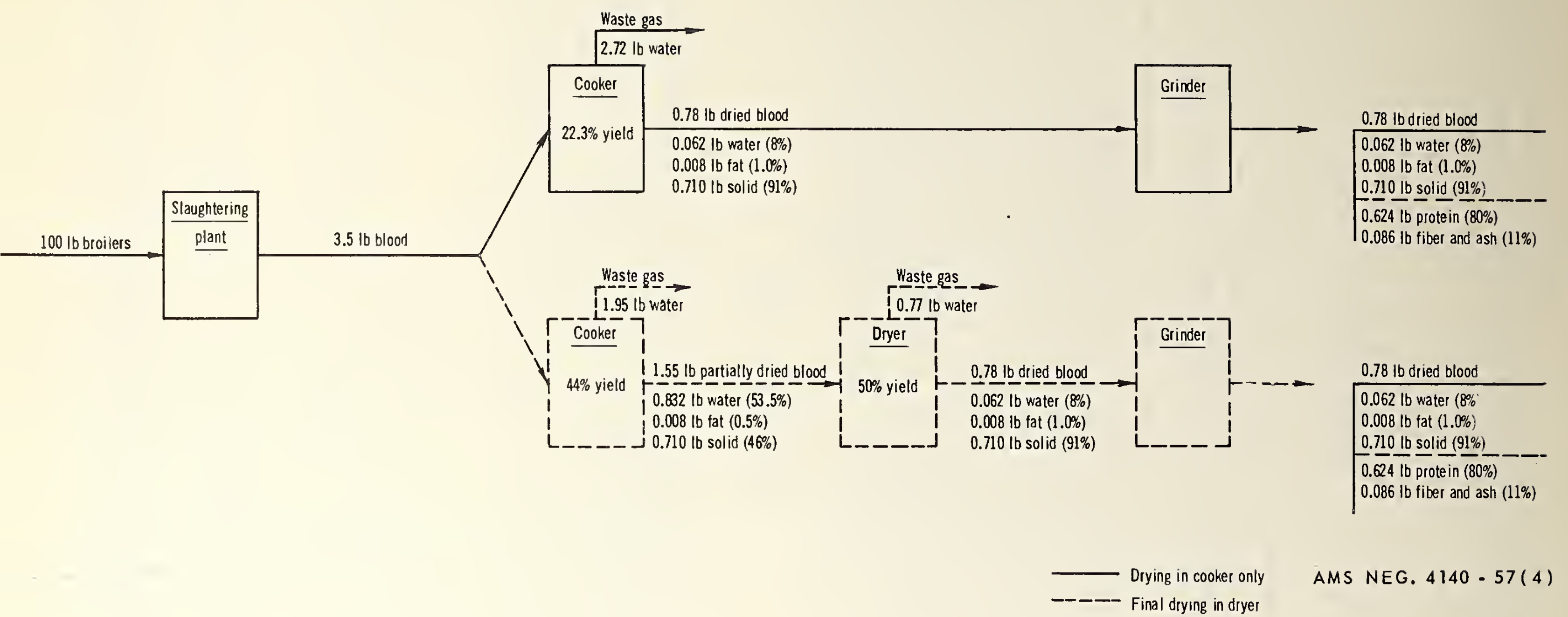

FIGURE 4. BROILER BLOOD PROCESSING

Labor Requirements

Estimation of labor requirements for different poultry-waste rendering plants was based primarily on observation of rendering operations and review of rendering plant records. Detailed estimates and discussions for different rendering plants are shown in Appendix E.

Fixed Capital

Estimates of fixed capital for different rendering plants were based on the equipment cost information obtained from equipment manufacturers and conventional estimating procedures described in the cost estimating literature. An installation cost estimate (including piping and electrical wiring) equal to 40 per cent of the purchased equipment cost was based on rendering plant estimates by equipment manufacturers and actual cost records on installation of equipment in a rendering plant. Water-well costs based on manufacturer's information were estimated at $2, 000 to $5, 000, depending on rendering plant size. Land costs were assumed somewhat arbitrarily at $1, 000 per acre with estimates of one-half to one acre of land required for the plants described.* Building costs were based on information covering typical steel frame buildings for rendering plants and were estimated at $6 per square foot. The physical plant cost was obtained by adding the water-well, land, and building cost to the installed equipment cost. The final fixed capital was obtained by adding 25 per cent to the physical plant cost for the contractor's fee and contingencies. Detailed fixed capital estimates for different types and sizes of rendering plants are described in Appendix D.

Market Price Data

Market prices for poultry by-products obtained from slaughterers and renderers during the plant visits indicated considerable variations from one locality to another. Nearness to consumers (especially broiler raisers), consumer acceptance of the particular product, and local competition were found to be dominant factors in determining the market price in a particular area. For calculation and comparison of the profitability of the plants considered in this study, a price of $1.10 per unit of protein contained in the products was used. On this basis the assumed market prices are:

Poultry By-Product Meal (55 units of protein)	$60.50 per ton
Tankage (unpressed) (49 units of protein)	53.90 per ton
Tankage (unpressed) plus Dried Blood (52.6 units of protein)	57.86 per ton
Dried Blood (80 units of protein)	88.00 per ton

*The range of land cost, estimated from observation of location of slaughterers and renderers visited, probably goes from under $500 to over $1500 per acre. In view of the small acreage involved, the use of an arbitrary average will not introduce significant error.

Feather Meal (85 units of protein)	$93.50 per ton
Mixed Meal (67.4 units of protein)	74.14 per ton

The price of $53.90 per ton for tankage was based on the assumption that the tankage could be sold to a renderer who could extract a marketable fat and prepare a poultry by-product meal. This assumption, of course, depends on the market for fat and the production of fat of a quality suitable for fat-fortifying feeds. A price of $0.08 per pound was assumed for good quality fat. A market price of $93.50 per ton for feather meal and $88 per ton for dried blood is based on the assumption that these materials can be sold for feed uses. If there is no market in the area for dried blood or feather meal in feeds, these materials might be sold for fertilizer use at a lower price.

Plant Costs, Product Costs, and Plant Layouts

Capital requirements, product costs, and gross profits were estimated for six different types of rendering plants, varying in size and to some extent, in the type of equipment used. Schematic layouts were also drawn for these plants and are presented with the cost data. In arriving at the estimated manufacturing cost, indirect costs covering such items as payroll overhead, laboratory expenses, plant overhead, packaging, and shipping were estimated at 50 per cent of the direct labor estimate[23]. The estimated product cost was obtained from the estimated manufacturing cost by adding 25 per cent for general expenses (administration, sales, research, and financing costs)[24]. The actual indirect costs and general expenses for a particular plant may be more or less than these estimates. Table 4 presents a brief summary of the major characteristics of these plants. Plant estimates are presented in Tables 5 through 26 in this section, and more detailed data is contained in Appendix D.

TABLE 4. CHARACTERISTICS OF THE RENDERING PLANTS DESCRIBED

	Cookers						
Plant	No.	Diam, ft	Length, ft	Special Equipment	Weekly Capacity[a], thousands of pounds broiler live weight	Estimated Capital, thousands of dollars	Estimated[a] Weekly Rendering Cost, dollars
A	1	4	7	--	68	37.0	458
B	2	4	7	--	136	63.6	634
C	2	4	7	1 press	324[b]	76.4	799[b]
D	2	4	7	1 dryer	272	77.8	948
E	2	5	12	--	340	88.9	1060
F	4	5	12	--	680	140.7	1728

(a) Based on rendering all wastes and operating a 5-day, 60-hour week.
(b) Based on rendering offal only and operating a 5-day, 60-hour week.

The following processing schemes were considered in preparing the cost estimates and in arriving at the six types of rendering plants described in succeeding pages:

(1) Processing of offal only to produce dry tankage. The estimates did not allow for the addition of blood to the charge. If this were done in an integrated plant, the slaughtering plant would have to be 20% smaller in capacity than if only offal were rendered.

(2) Processing of feathers only. This procedure was expected to yield the highest by-product value per unit of slaughtering capacity, while leaving the problem of disposing of the more perishable blood and offal unsolved in an integrated plant.

(3) Separate processing of blood and offal in one or more cookers, and separate processing of feathers in one or more cookers. This appeared to be a procedure worthy of consideration in integrated plants having at least two processing lines (cookers, or cooker-dryer combinations) since it would handle all wastes.

(4) Processing a mixture of all wastes. This method is the simplest from a control standpoint, produces a grindable product (offal processing without pressing does not), and seemed to be well suited to the small single-cooker integrated plant.

With processing schemes (1) and (2) some other method of disposing of the feathers and the offal and blood must be available. In some areas renderers pick up and pay for these wastes, in other areas renderers pick up these wastes at no charge, and in some areas renderers are not interested in these wastes. The situation in a particular locality depends on the length of haul required, the general availability of all types of slaughtering wastes, and the local demand for poultry by-product feed supplements. On the east coast feathers have sold for as much as $13 per ton (based on 10 per cent of the live weight) where the length of haul is short. Reported prices for offal ranged from $1 to $10 per ton. Prices as high as $10 per ton were paid only for clean, fresh offal a short distance away.

Plant A. One 4 x 7 Cooker

A plant consisting of one 4 x 7 cooker, a grinder, a boiler, and auxiliary equipment was estimated to require a fixed capital of $37,000. A summary of the capital cost estimate is shown in Table 5; a more detailed estimate is shown in Appendix Table D-14. Estimated raw waste capacity in terms of slaughtering volume and estimated by-product output for several types of processing operations are shown in Table 6. Estimated product costs for these operations are summarized in Table 7, while Table 8 shows estimated profits for these operations. A sample layout for this type of plant appears in Figure 5.

As an independent rendering plant, this unit is definitely unprofitable and impractical. This plant could most easily be used to perform one of three types of operations: (1) Production of mixed meal; (2) production of dry tankage from offal or blood-offal mixtures, and (3) production of feather meal from wet feathers. In the latter case, sale of offal is often possible. With efficient management, the labor costs shown could be cut in half (only a part-time operator is really needed in such a small plant), producing a weekly credit of about $124. When labor is thus optimized, such a small rendering plant, supplied with feathers from a slaughtering unit processing 136,000 pounds live weight per week, might just about break even.

All other schemes outlined in Table 8 would show a loss, even with optimum labor efficiency.

TABLE 5. ESTIMATED FIXED CAPITAL FOR PLANT A[(a)]

	Dollars
Equipment Cost	15,900
Installation (40% of equipment cost)	6,400
Land, Building, and Well Cost	7,300
Physical Plant Cost	29,600
Contractor's Fee and Contingency (25% of physical plant cost)	7,400
Fixed Capital	37,000[(b)]

(a) Includes one 4 x 7 foot cooker, grinder, boiler, and auxiliary equipment.

(b) For producing tankage, the grinder and associated equipment are not required, and fixed capital is reduced to $33,573.

TABLE 6. PLANT A. ESTIMATED RAW WASTE CAPACITY AND BY-PRODUCT OUTPUT

Basis: 12-Hour Day, 5-Day Week

	Processing			
			All Wastes	
	Offal Only	Feathers Only	Separate	Mixed
Slaughtering Plant, thousand pounds live weight per week	162	136	68	68
Tankage, tons/week	4.70	--	2.24	--
Feather Meal, tons/week	--	3.74	1.87	--
Mixed Meal, tons/week	--	--	--	4.11
Water Evaporated, tons/week	10.29	11.22	10.85	10.85

TABLE 7. ESTIMATED WEEKLY PRODUCT COSTS FOR PLANT A

Basis: 12 Hours per Day, 5 Days per Week, 50 Weeks per Year

	Dollars per Week		
	Offal Only	Feathers Only	All Wastes
Labor, 60 Hours	120.00	120.00	120.00
Supervision, 10% of Labor	12.00	12.00	12.00
Fuel, $3.53/Ton Water Evap.	36.32	39.61	38.30
Electricity, $1.06/Ton Water Evap.	10.91	11.89	11.50
Water, $0.40/Ton Water Evap.	4.12	4.49	4.34
Maintenance, 5% of Fixed Capital per Year	33.57	37.00	37.00
Miscellaneous, 25% of Maintenance	8.39	9.25	9.25
Depreciation, 8% of Fixed Capital per Year	53.72	59.20	59.20
Taxes and Insurance, 2% of Fixed Capital per Year	13.43	14.80	14.80
Estimated Direct Cost	292.46	308.24	306.39
Indirect Cost, 50% of Labor	60.00	60.00	60.00
Estimated Manufacturing Cost	352.46	368.24	366.39
General Expenses, 25% of EMC	88.12	92.06	91.60
Estimated Product Cost	440.58	460.30	457.99

TABLE 8. ESTIMATED WEEKLY PROFIT FOR PLANT A

Basis: 12-Hour Day, 5-Day Week

	Processing			
			All Wastes	
	Offal Only	Feathers Only	Separate	Mixed
	Dollars per Week			
Tankage	253	--	130	--
Feather Meal	--	350	175	--
Mixed Meal	--	--	--	305
Total Sales Value	253	350	305	305
Estimated Product Cost	441	460	458	458
Estimated Gross Profit	-188	-110	-153	-153

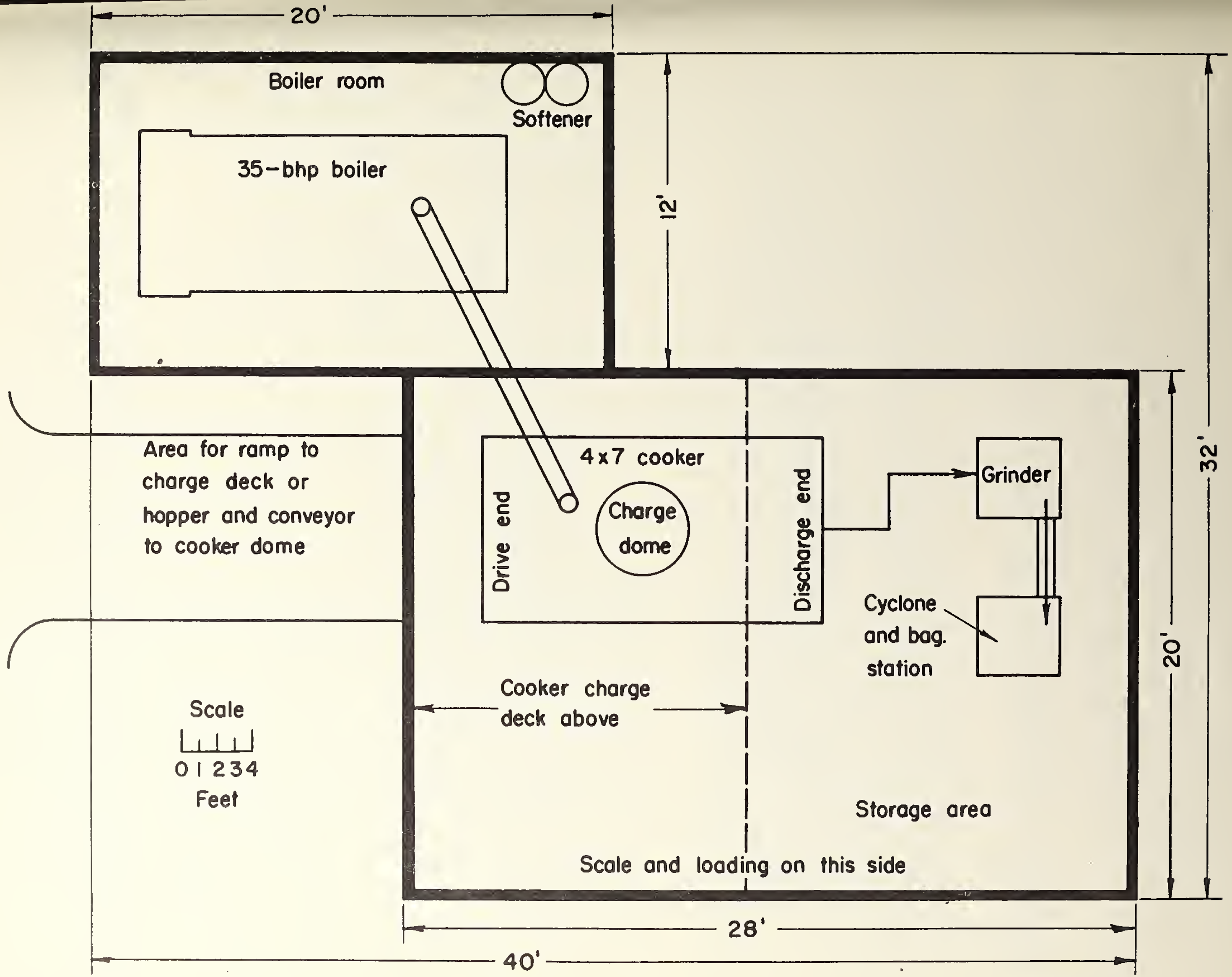

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FIGURE 5. SAMPLE LAYOUT FOR PLANT A

Plant B. Two 4 x 7 Cookers

A plant consisting of two 4 x 7 cookers, a grinder, a boiler, and auxiliary equipment has an estimated fixed capital requirement of $63,570. This fixed capital estimate is summarized in Table 9; a detailed estimate is shown in Appendix Table D-15. Estimated raw waste capacity in terms of slaughtering volume and estimated by-product output for several types of processing operations are shown in Table 10. Estimated product costs for these operations are summarized in Table 11, while Table 12 shows estimated gross profits for these operations, and Figure 6 shows a suggested layout for the plant.

This plant is very similar to Plant A, except that it has twice the cooker volume and should utilize its labor more efficiently, even if separated from the slaughtering operation.

This plant could probably be operated four ways: (1) processing offal (or offal and blood) to dry tankage; (2) processing feathers; (3) processing offal (or offal and blood) in one cooker to dry tankage, and feathers in the other cooker to feather meal; or (4) processing combined wastes in both cookers to produce a mixed meal. Process (2) shows a profit of $60 per week, where feathers from 272,000 pounds broiler live weight per week are available. This weekly profit is equivalent to $8.02 per ton of feather meal and 4.7 per cent return on investment before income taxes. The other processes show losses, although the loss for processes (3) and (4) is $3.05 per ton of product which is equivalent to only $1.31 per ton of raw waste (based on raw waste equal to 28 per cent of live weight).

Plant C. Two 4 x 7 Cookers and a Press

The plant discussed in the preceding section can be expanded to include a press and its auxiliaries. Such a plant has an estimated fixed capital of $76,370 (see Appendix Table D-16 for details). The total weight of products obtained from this plant would be the same as from Plant B. Table 13 shows that the estimated added weekly product cost for separate production of fat from offal would be about $187, bringing the total weekly product cost to about $798. The loss, listed as $105 per week for Plant B, would become $127 per week for Plant C, as Table 14 shows. Since the sales value of the fat was assumed at the peak level of 8 cents per pound, a price obtainable only for the highest grade of chicken fat, pressing of fat on the small scale of Plant C definitely appears uneconomical.

Cursory estimates suggested that slaughtering volumes of over one million pounds per week might make recovery of fat economically feasible.

Plant D. Two 4 x 7 Cookers, One Dryer

A plant with a steam-tube dryer, in addition to two 4 x 7 cookers, a grinder, and a boiler is estimated to require a fixed capital of $77,820. Table 15 summarizes the fixed capital estimates; further details will be found in Appendix Table D-17. The estimated raw waste capacity in terms of slaughtering weight and the estimated by-product output for various processing schemes are shown in Table 16. Estimated product costs for these schemes are shown in Table 17, with estimated gross profits summarized in Table 18. A schematic plant layout is shown in Figure 7.

TABLE 9. ESTIMATED FIXED CAPITAL FOR PLANT B[a]

	Dollars
Equipment Cost	26,070
Installation (40% of equipment cost)	10,500
Land, Building, and Well Cost	14,300
Physical Plant Cost	50,870
Contractor's Fee and Contingency (25% of physical plant cost)	12,700
Fixed Capital	63,570[b]

(a) Includes two 4 x 7 foot cookers, grinder, boiler, and auxiliary equipment.
(b) For producing tankage, grinder and associated equipment are not required, and fixed capital is reduced to $59,945.

TABLE 10. PLANT B. ESTIMATED RAW WASTE CAPACITY AND BY-PRODUCT OUTPUT

Basis: 12-Hour Day, 5-Day Week

	Processing			
			All Wastes	
	Offal Only	Feathers Only	Separate	Mixed
Slaughtering Plant, thousand pounds live weight per week	324	272	136	136
Tankage, tons/week	9.40	--	4.47	--
Feather Meal, tons/week	--	7.48	3.74	--
Mixed Meal, tons/week	--	--	--	8.21
Water Evaporated, tons/week	20.57	22.44	21.71	21.71

TABLE 11. ESTIMATED WEEKLY PRODUCT COSTS FOR PLANT B

Basis: 12 Hours per Day, 5 Days per Week, 50 Weeks per Year

	Dollars per Week		
	Offal Only	Feathers Only	All Wastes
Labor, 60 Hours	120.00	120.00	120.00
Supervision, 10% of Labor	12.00	12.00	12.00
Fuel, \$3.53 Ton Water Evap.	72.61	79.21	76.64
Electricity, \$1.06/Ton Water Evap.	21.80	23.79	23.01
Water, \$0.40/Ton Water Evap.	8.23	8.98	8.68
Maintenance, 5% of Fixed Capital per Year	59.94	63.60	63.60
Miscellaneous, 25% of Maintenance	14.99	15.90	15.90
Depreciation, 8% of Fixed Capital per Year	95.91	102.00	102.00
Taxes and Insurance, 2% of Fixed Capital per Year	23.98	25.40	25.40
Estimated Direct Cost	429.46	450.88	447.23
Indirect Cost, 50% of Labor	60.00	60.00	60.00
Estimated Manufacturing Cost	489.46	510.88	507.23
General Expenses, 25% of EMC	122.37	127.72	126.81
Estimated Product Cost	611.83	638.60	634.04

TABLE 12. ESTIMATED WEEKLY PROFIT FOR PLANT B

Basis: 12-Hour Day, 5-Day Week

	Processing			
			All Wastes	
	Offal Only	Feathers Only	Separate	Mixed
	Dollars per Week			
Tankage	507	--	259	--
Feather Meal	--	699	350	--
Mixed Meal	--	--	--	609
Total Sales Value	507	699	609	609
Estimated Product Cost	612	639	634	634
Estimated Gross Profit	-105	60	-25	-25

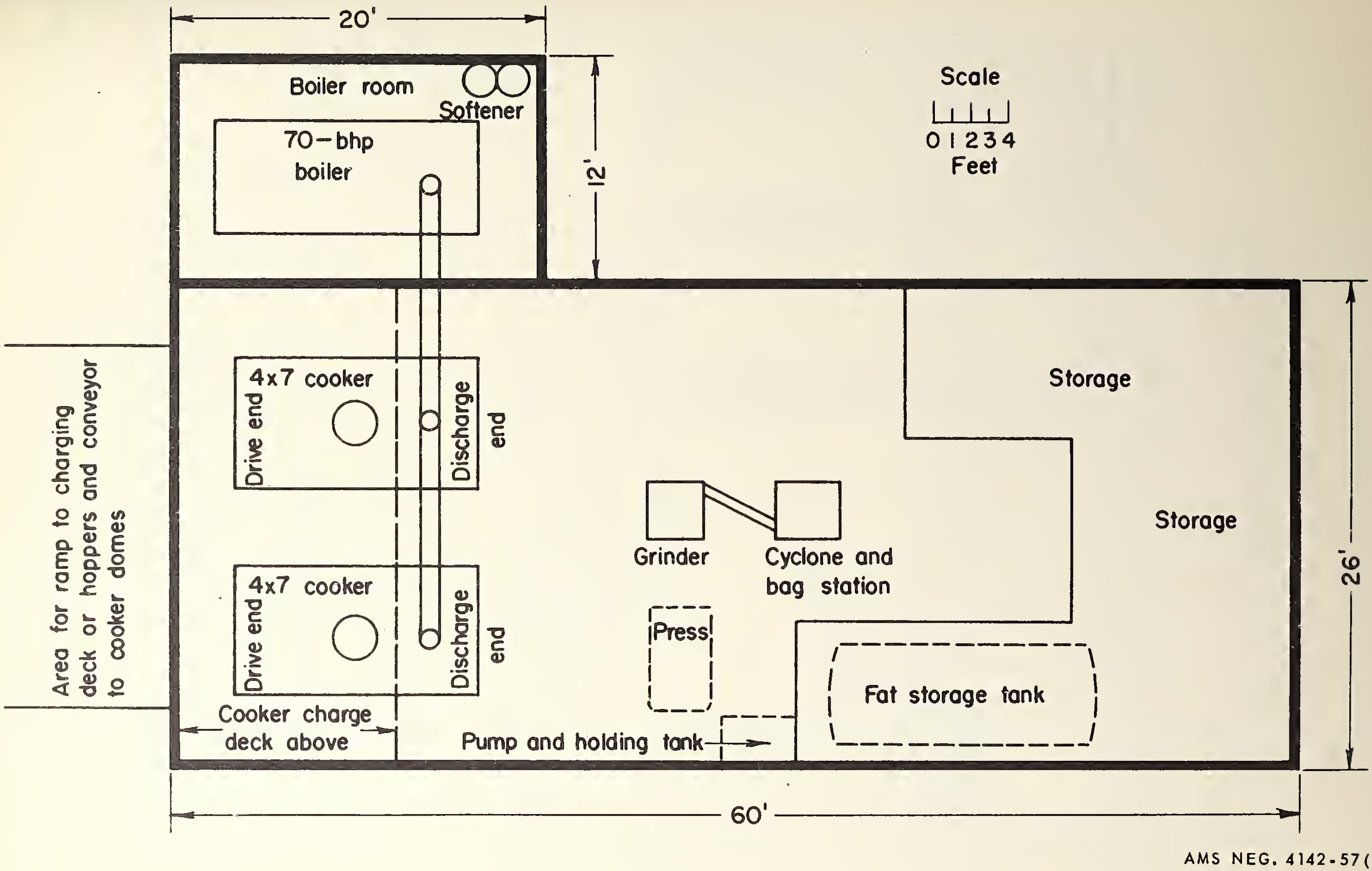

FIGURE 6. SAMPLE LAYOUT FOR PLANT B AND PLANT C

TABLE 13. ESTIMATED ADDITIONAL PRODUCT COSTS FOR ADDING A PRESS TO PLANT B (PLANT C)

	Offal Processing, dollars per week		
	Plant B	Added Cost for C	Plant C
Labor, 60 Hours	120.00	60.00	180.00
Supervision, 10% of Labor	12.00	6.00	18.00
Fuel, $3.53/Ton Water Evap.	72.61	None	72.61
Electricity, $1.06/Ton Water Evap.	21.80	Not estimated	21.80
Water, $0.40/Ton Water Evap.	8.23	None	8.23
Maintenance, 5% of Fixed Capital per Year	59.94	16.46	76.40
Miscellaneous, 25% of Maintenance	14.99	4.11	19.10
Depreciation, 8% of Fixed Capital per Year	95.91	26.54	122.45
Taxes and Insurance, 2% of Fixed Capital per Year	23.98	6.53	30.51
Estimated Direct Cost	429.46	119.64	549.10
Indirect Cost, 50% of labor	60.00	30.00	90.00
Estimated Manufacturing Cost	489.46	149.64	639.10
General Expenses, 25% of EMC	122.37	37.41	159.78
Estimated Product Cost	611.83	187.05	798.88

TABLE 14. COMPARISON OF WEEKLY PROFITS OF PLANTS B AND C (OFFAL PROCESSING)

Plant	B	C
Output		
Dry Tankage, tons/week	9.40	--
Poultry By-Product Meal, tons/week	0	8.36
Poultry Fat, tons/week	0	1.04
Sales		
Dry Tankage, $/week	507	--
Poultry By-Product Meal, $/week	--	506
Poultry Fat, $/week	--	166
Total Sales Value	507	672
Estimated Product Cost, $/week	612	799
Estimated Gross Profit, $/week	-105	-127

TABLE 15. ESTIMATED FIXED CAPITAL FOR PLANT D[a]

	Dollars
Equipment Cost	32,770
Installation (40% of equipment cost)	13,100
Land, Building, and Well Cost	16,350
Physical Plant Cost	62,220
Contractor's Fee and Contingency (25% of physical plant cost)	15,600
Fixed Capital	77,820[b]

(a) Includes two 4 x 7 foot cookers, grinder, boiler, steam-tube dryer, and auxiliary equipment.
(b) For producing tankage, grinder and associated equipment are not required, and fixed capital is $73,008.

TABLE 16. PLANT D. ESTIMATED RAW WASTE CAPACITY AND BY-PRODUCT OUTPUT

Basis: 12-Hour Day, 5-Day Week

	Processing		
	Offal Only	Feathers Only	All Wastes Mixed
Slaughtering Plant, thousand pounds live weight per week	650	785	272
Tankage, tons/week	18.85	--	--
Feather Meal, tons/week	--	21.59	--
Mixed Meal, tons/week	--	--	16.43
Water Evaporated, tons/week	41.28	64.76	43.41

TABLE 17. ESTIMATED WEEKLY PRODUCT COSTS FOR PLANT D

Basis: 12 Hours per Day, 5 Days per Week, 50 Weeks per Year

	Dollars per Week		
	Offal Only	Feathers Only	All Wastes
Labor, 90 Hours	180.00	180.00	180.00
Supervision, 10% of Labor	18.00	18.00	18.00
Fuel, $3.53/Ton Water Evap.	145.72	228.60	153.24
Electricity, $1.06/Ton Water Evap.	43.76	68.65	46.01
Water, $0.40/Ton Water Evap.	16.51	25.90	17.36
Maintenance, 5% of Fixed Capital per Year	73.01	77.80	77.80
Miscellaneous, 25% of Maintenance	18.25	19.50	19.50
Depreciation, 8% of Fixed Capital per Year	116.81	124.60	124.60
Taxes and Insurance, 2% of Fixed Capital	29.20	31.70	31.70
Estimated Direct Cost	641.26	774.75	668.21
Indirect Cost, 50% of Labor	90.00	90.00	90.00
Estimated Manufacturing Cost	731.26	864.75	758.21
General Expense, 25% of EMC	182.82	216.19	189.55
Estimated Product Cost	914.08	1,080.94	947.76

TABLE 18. ESTIMATED WEEKLY PROFIT FOR PLANT D

Basis: 12-Hour Day, 5-Day Week

	Processing		
	Offal Only	Feathers Only	All Wastes
	Dollars per Week		
Tankage	1,016	--	--
Feather Meal	--	2,019	--
Mixed Meal	--	--	1,218
Total Sales Value	1,016	2,019	1,218
Estimated Product Cost	914	1,081	948
Estimated Gross Profit	102	938	270

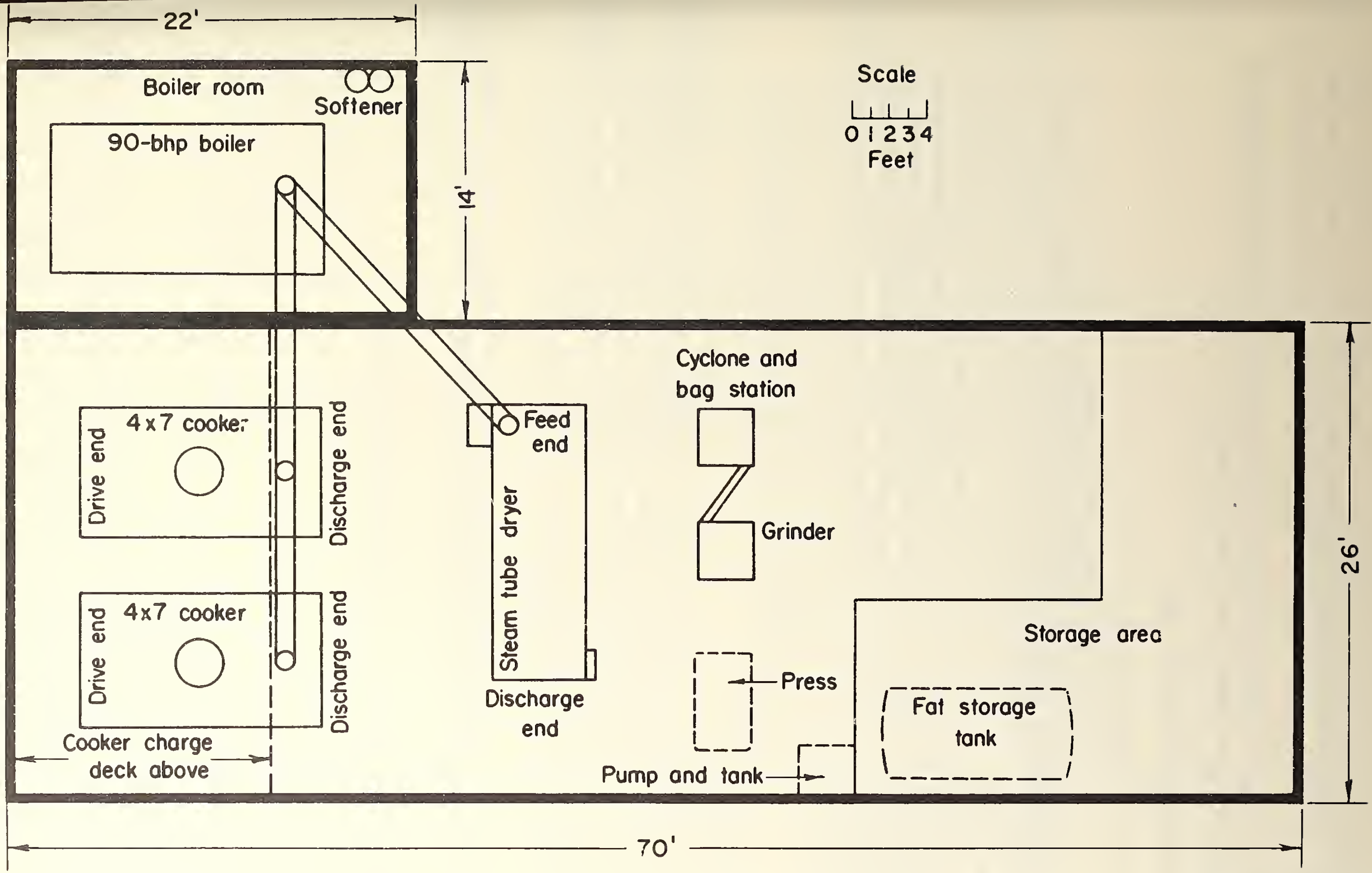

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FIGURE 7. SAMPLE LAYOUT FOR PLANT D

Addition of a dryer gives this plant twice as much capacity as Plant B at an increase in investment of only about 22 per cent. The single dryer, however, would probably make separate processing of different wastes difficult, if not impossible. As a result, only the following three processing schemes were considered in Table 18:

(1) Processing of offal only (blood could be mixed in, dropping slaughtering capacity but keeping profit about the same).

(2) Processing of feathers only.

(3) Processing mixed wastes.

Each of the three processing schemes is profitable. Scheme (2) looks quite profitable, processing the feathers from 785, 000 pounds broiler live weight per week giving an estimated profit of $938 per week, which is equivalent to 60.3 per cent gross return on investment. Scheme (1) shows the least profit – $102 per week (7 per cent return) by processing the offal from 650, 000 pounds broiler live weight per week. Plant D differs from Plant B primarily in the addition of a dryer. The dryer doubles the capacity to produce tankage from offal and the capacity to produce mixed meal from combined wastes, and nearly triples the feather meal capacity. This greater increase in the capacity for feather meal explains the big increase in the profitability of producing feather meal.

Plant E. Two 5 x 12 Cookers

A plant consisting of two 5 x 12 cookers, a grinder, and a broiler was estimated to require a fixed capital of $88, 930. Table 19 summarizes the fixed capital estimate; the detailed estimate will be found in Appendix Table D-18. Estimated raw waste capacity in terms of slaughtering volume and estimated by-product output for several processing schemes are shown in Table 20. Estimated product costs for these schemes are shown in Table 21, while estimated gross profits are shown in Table 22, and the sample plant layout appears in Figure 8.

This plant has about 25 per cent more capacity than Plant D, while the increase in fixed capital is only about 14 per cent, which leads to lower fixed charges, as shown in Table 21.

Four operating schemes were evaluated for this plant:

(1) Processing offal only

(2) Processing feathers only

(3) Processing offal and blood in one line and feathers in the other line

(4) Processing mixed wastes.

Scheme (1) shows the least and Scheme (2) the greatest profit. Processing the offal from 810, 000 pounds broiler live weight per week gives an estimated profit for Scheme (1) of $243 per week, which is equivalent to 17.4 per cent gross return on investment. With feathers from 655, 000 pounds broiler live weight per week, the profit

TABLE 19. ESTIMATED FIXED CAPITAL FOR PLANT E[a]

	Dollars
Equipment Cost	35,230
Installation (40% of equipment cost)	14,100
Land, Building, and Well Cost	21,800
Physical Plant Cost	71,130
Contractor's Fee and Contingency (25% of physical plant cost)	17,800[b]
Fixed Capital	88,930

(a) Includes two 5 x 12 foot cookers, grinder, boiler, and auxiliary equipment.

(b) For producing tankage, the grinder and associated equipment are not required, and fixed capital is reduced to $84,125.

TABLE 20. PLANT E. ESTIMATED RAW WASTE CAPACITY AND BY-PRODUCT OUTPUT

Basis: 12-Hour Day, 5-Day Week

	Processing			
			All Wastes	
	Offal Only	Feathers Only	Separate	Mixed
Slaughtering Plant, thousand pounds live weight per week	810	655	340	340
Tankage, tons/week	23.49	--	11.19	--
Feather Meal, tons/week	--	18.01	9.35	--
Mixed Meal, tons/week	--	--	--	20.54
Water Evaporated, tons/week	51.44	54.04	54.26	54.26

TABLE 21. ESTIMATED WEEKLY PRODUCT COSTS FOR PLANT E

Basis: 12 Hours per Day, 5 Days per Week, 50 Weeks per Year

	Dollars per Week		
	Offal Only	Feathers Only	All Wastes
Labor, 90 Hours	180.00	180.00	180.00
Supervision, 10% of Labor	18.00	18.00	18.00
Fuel, $3.53/Ton Water Evap.	181.58	190.76	191.54
Electricity, $1.06/Ton Water Evap.	54.53	57.28	57.52
Water, $0.40/Ton Water Evap.	20.58	21.62	21.70
Maintenance, 5% of Fixed Capital per Year	84.13	89.00	89.00
Miscellaneous, 25% of Maintenance	21.03	22.00	22.00
Depreciation, 8% of Fixed Capital per Year	134.60	142.00	142.00
Taxes and Insurance, 2% of Fixed Capital per Year	33.65	36.00	36.00
Estimated Direct Cost	728.10	756.66	757.76
Indirect Cost, 50% of Labor	90.00	90.00	90.00
Estimated Manufacturing Cost	818.10	846.66	847.76
General Expense, 25% of EMC	204.52	211.67	211.94
Estimated Product Cost	1,022.62	1,058.33	1,059.70

TABLE 22. ESTIMATED WEEKLY PROFIT FOR PLANT E

Basis: 12-Hour Day, 5-Day Week

	Processing			
			All Wastes	
	Offal Only	Feathers Only	Separate	Mixed
	Dollars per Week			
Tankage	1,266	--	648	--
Feather Meal	--	1,684	875	--
Mixed Meal	--	--	--	1,523
Total Sales Value	1,266	1,684	1,523	1,523
Estimated Product Cost	1,023	1,058	1,060	1,060
Estimated Gross Profit	243	626	463	463

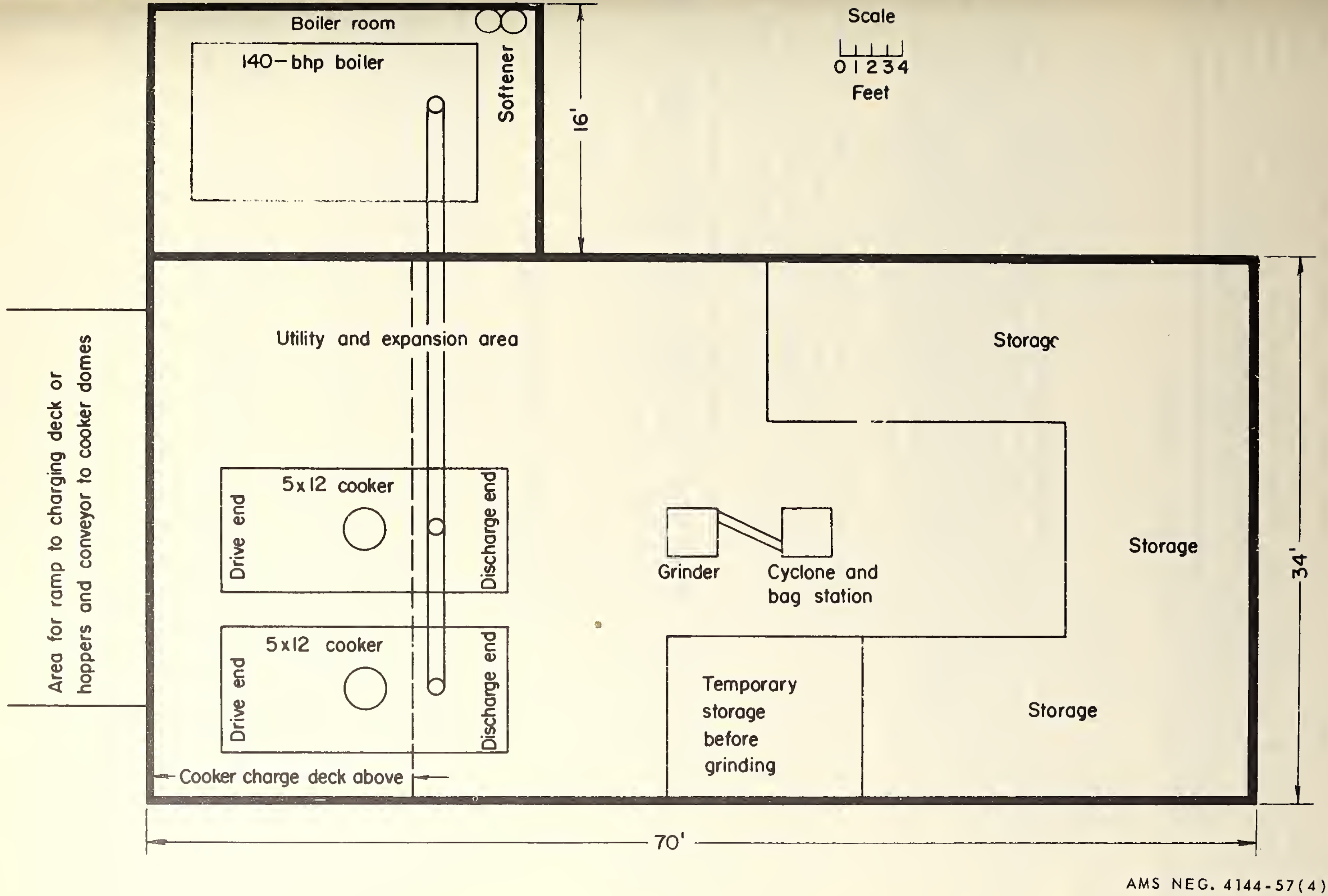

FIGURE 8. SAMPLE LAYOUT FOR PLANT E

for Scheme (2) is $626 per week (35.2 per cent gross return). This plant, with two 5 x 12 cookers, has 25 per cent more capacity for offal or mixed meal than Plant D, with two 4 x 7 cookers and a dryer, and shows more profit with tankage and mixed meal than Plant D. The two 5 x 12 cookers actually have about 17 per cent less capacity than Plant D with two 4 x 7 cookers and a dryer, and show less profit – $626 per week compared with $938 per week. The drop in estimated gross return is even greater (35.2 per cent compared with 60.3 per cent) because the fixed capital is larger. These results indicate that it may be preferable to obtain the desired feather meal capacity by including a dryer and reducing the cooker capacity.

Plant F. Four 5 x 12 Cookers

A plant consisting of four 5 x 12 cookers, a grinder, a boiler, and the necessary auxiliary equipment was estimated to require a fixed capital of $140,700. Table 23 summarizes the fixed capital estimate; Appendix Table D-19 shows the detailed estimate. Estimated raw waste capacity in terms of slaughtering volume, and by-product output are shown in Table 24 for various processing schemes. Estimated weekly product costs for these schemes are shown in Table 25 with estimated weekly gross profits summarized in Table 26. Figure 9 is a schematic layout of such a plant.

This is the largest rendering unit that was considered in this study. Its capacity in terms of slaughtering volume ranges from 680,000 pounds live weight per week to over 1.5 million pounds live weight per week, depending on the operating scheme selected. When offal only, or offal and blood, is rendered, the pressing of fat might be a profitable additional operation. Even with tankage processing (where the lowest profit is obtained) the gross return on investment (before Federal Income Tax) was estimated to be over 46 per cent. This plant is evidence of a fact suspected at the beginning of this study, namely, that an integrated rendering operation is quite feasible economically, if the slaughtering volume connected with it is sufficiently large.

DISCUSSION AND CONCLUSIONS

The preceding section shows that the profitability of a rendering plant depends not only on its size but also on the way it is operated. Generally, the production of tankage from offal provides the lowest margin, and the rendering of feathers to the exclusion of all other wastes may be the operation with the greatest margin. The purpose of this discussion is to relate these data, if possible, more closely to the needs of poultry processors. Of particular interest is the size of slaughtering operation that would justify an integrated waste-processing plant.

To make such an evaluation, it is necessary to make some generalizations that will narrow down the number of processing alternatives for any given size of slaughtering operation. It is believed that several such generalizations are possible, which will greatly simplify the subsequent discussions.

TABLE 23. ESTIMATED FIXED CAPITAL FOR PLANT F[a]

	Dollars
Equipment Cost	61,180
Installation (40% of equipment cost)	24,420
Land, Building, and Well Cost	27,000
Physical Plant Cost	112,600
Contractor's Fee and Contingency (25% of physical plant cost)	28,100
Fixed Capital	140,700[b]

(a) Includes four 5 x 12 foot cookers, grinder, boiler, and auxiliary equipment.
(b) For producing tankage, the grinder and associated equipment are not required, and fixed capital is reduced to $134,725.

TABLE 24. PLANT F. ESTIMATED RAW WASTE CAPACITY AND BY-PRODUCT OUTPUT

Basis: 12-Hour Day, 5-Day Week

	Processing			
			All Wastes	
	Offal Only	Feathers Only	Separate	Mixed
Slaughtering Plant, thousand pounds live weight per week	1,620	1,310	680	680
Tankage, tons/week	46.98	--	22.37	--
Feather Meal, tons/week	--	36.03	18.70	--
Mixed Meal, tons/week	--	--	--	41.07
Water Evaporated, tons/week	102.87	108.08	108.53	108.53

TABLE 25. ESTIMATED WEEKLY PRODUCT COSTS FOR PLANT F

Basis: 12 Hours per Day, 5 Days per Week, 50 Weeks per Year

	Dollars per Week		
	Offal Only	Feathers Only	All Wastes
Labor, 120 Hours	240	240	240
Supervision, 10% of Labor	24	24	24
Fuel, \$3.53/Ton Water Evap.	363	382	383
Electricity, \$1.06/Ton Water Evap.	109	115	115
Water, \$0.40/Ton Water Evap.	41	43	43
Maintenance, 5% of Fixed Capital per Year	135	141	141
Miscellaneous, 25% of Maintenance	34	35	35
Depreciation, 8% of Fixed Capital per Year	216	225	225
Taxes and Insurance, 2% of Fixed Capital per Year	54	56	56
Estimated Direct Cost	1,216	1, 261	1, 262
Indirect Cost, 50% of Labor	120	120	120
Estimated Manufacturing Cost	1, 336	1, 381	1, 382
General Expense, 25% of EMC	334	345	346
Estimated Product Cost	1, 670	1, 726	1, 728

TABLE 26. ESTIMATED WEEKLY PROFIT FOR PLANT F

Basis: 12-Hour Day, 5-Day Week

	Processing			
			All Wastes	
	Offal Only	Feathers Only	Separate	Mixed
	Dollars per Week			
Tankage	2, 532	--	1, 296	--
Feather Meal	--	3, 369	1, 749	--
Mixed Meal	--	--	--	3, 045
Total Sales Value	2, 532	3, 369	3, 045	3, 045
Estimated Product Cost	1, 670	1, 726	1, 728	1, 728
Estimated Gross Profit	862	1, 643	1, 317	1, 317

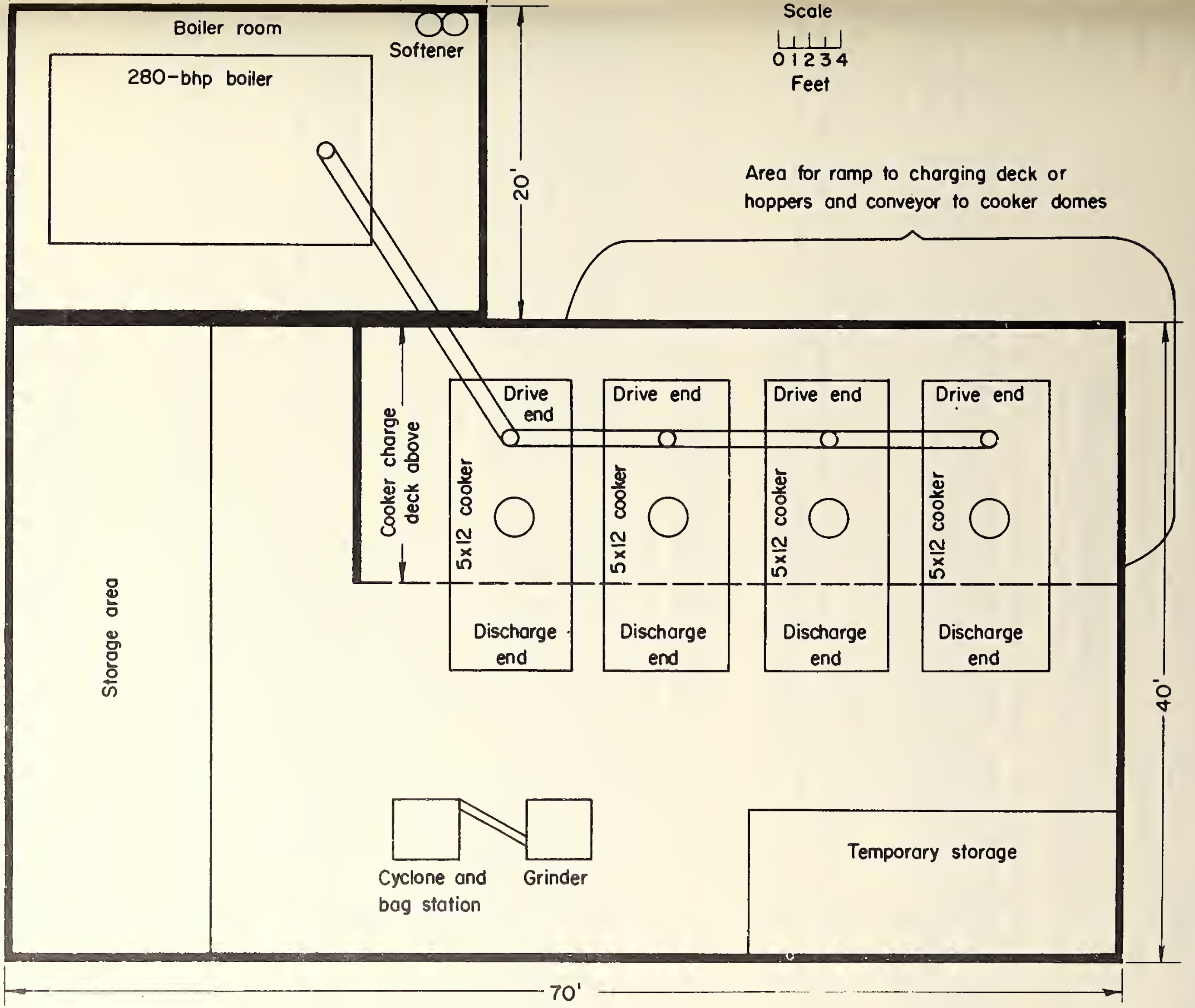

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FIGURE 9. SAMPLE LAYOUT FOR PLANT F

Production of Chicken Fat

The cost analysis on Plant C in the preceding section suggested that production of chicken fat can be ruled out for slaughterers killing less than one million pounds live weight per week. This type of operation will therefore be eliminated from further consideration.

Processing Separate Wastes

As indicated by the rather limited attention paid to the separate processing of blood in previous sections, this is believed to be rather impractical because of the low volume of material handled. A single charge of blood to a 4 x 7 cooker, for instance, requires the slaughtering of about 86, 000 pounds of broiler live weight (see Appendix Table D-4).

It is also doubtful whether it is practical to process separate wastes alternately i any one cooker, since this would require additional storage, probably increased labor and supervision cost, and may also lead to degradation of end-products (caused by extended storage of raw waste).

Round-the-Clock Operations

The plant cost and product cost estimates show that, with the smaller rendering plants, charges bearing a fairly fixed relation to capital (e.g., maintenance, depreciation, insurance, local taxes) make up a large portion of the product cost. Round-the-clock operation, even if limited to five 24-hour days per week, would increase greatly the product tonnage over which these charges could be spread, and thus increase operating margins.

This proposition was not studied in any detail because there are several problem connected with it which cannot be evaluated without additional knowledge about the economics of the poultry-slaughtering operation. For instance, if rendering is to be done on a 24-hour basis, the slaughtering operation should probably go on the same schedule for greatest efficiency and minimization of waste spoilage. This may present labor and management problems that make such a scheme impractical.

It is believed that the possibility of round-the-clock operation should be given consideration in future studies of the poultry-processing industry, since there seems t be at least some possibility that it may make rendering more attractive for the small operator.

Fowl and Turkey Slaughtering

Most of this study has dealt with the rendering of broiler wastes, partly because the processing of broilers represents the major activity in the industry and partly because broilers are the only product of the industry which is sufficiently uniform in its characteristics to allow estimation of reliable average yields for process calculations.

The limited information on fowl suggested higher total rendered waste yields than could be obtained from broilers, all the increase being ascribable to higher offal yields. The high fat content prevents manufacture of a mixed meal from offal without pressing. This means that the smallest practical integrated rendering plant is probably a two-cooker unit with separate processing of offal and feathers (blood being discarded or processed with the offal). The high fat content of any tankage produced will require handling some free fat, which separates from the tankage without pressing. It is believed that, as a first approximation, the conclusions drawn in connection with broiler processing will also apply to fowl.

The limited data on turkeys suggest that, as in the case of fowls, high fat content eliminates production of by-product meal from mixed wastes. Feather yield may be the highest with this type of bird, which may offset the effect of slightly lower total rendered product yield. Again, it appears that the general conclusions based on broiler processing should be applicable as at least a first approximation.

Comparison of Rendering Plants

The preferred operation evaluated here is the production of mixed meal from combined wastes (provided that a market exists or can be developed for the mixed meal). This operation will dispose of all wastes from the slaughtering plant and is estimated to yield a profit (see Figure 10) in the case of Plant D which would require the combined wastes from 272, 000 pounds broiler live weight per week. Even Plant B producing mixed meal comes close to breaking even with the combined wastes from only 136, 000 pounds broiler live weight per week. Producing feather meal from 272, 000 pounds broiler live weight per week (Plant B) will also yield a profit, but other outlets must exist or be found for the offal and blood. Production of tankage from offal is the least attractive procedure for a particular plant or for any specific slaughtering rate. The smallest offal rendering operation estimated to be profitable is Plant D processing the offal from 650, 000 pounds live weight per week.

Gross returns on investment for the five plants producing three different by-products are summarized in Figure 10. The greater profitability of feather meal production over mixed meal or tankage production is clearly illustrated. Figure 11 summarizes the estimated profit or loss of the five plants in dollars per ton of product. Figure 12 shows the estimated profits or losses as dollars per ton of raw waste.

It is believed that the following conclusions on rendering poultry wastes can be drawn from this study:

(1) At slaughtering volumes under 100, 000 pounds of live weight per week, the losses involved in operating a rendering plant would seem to exceed the costs presently incurred by a slaughterer in merely getting rid of his wastes by any other method.

(2) At slaughtering volumes between 100, 000 and 300, 000 pounds of live weight per week, a rendering operation may cost no more (and possibly less) than current disposal procedures.

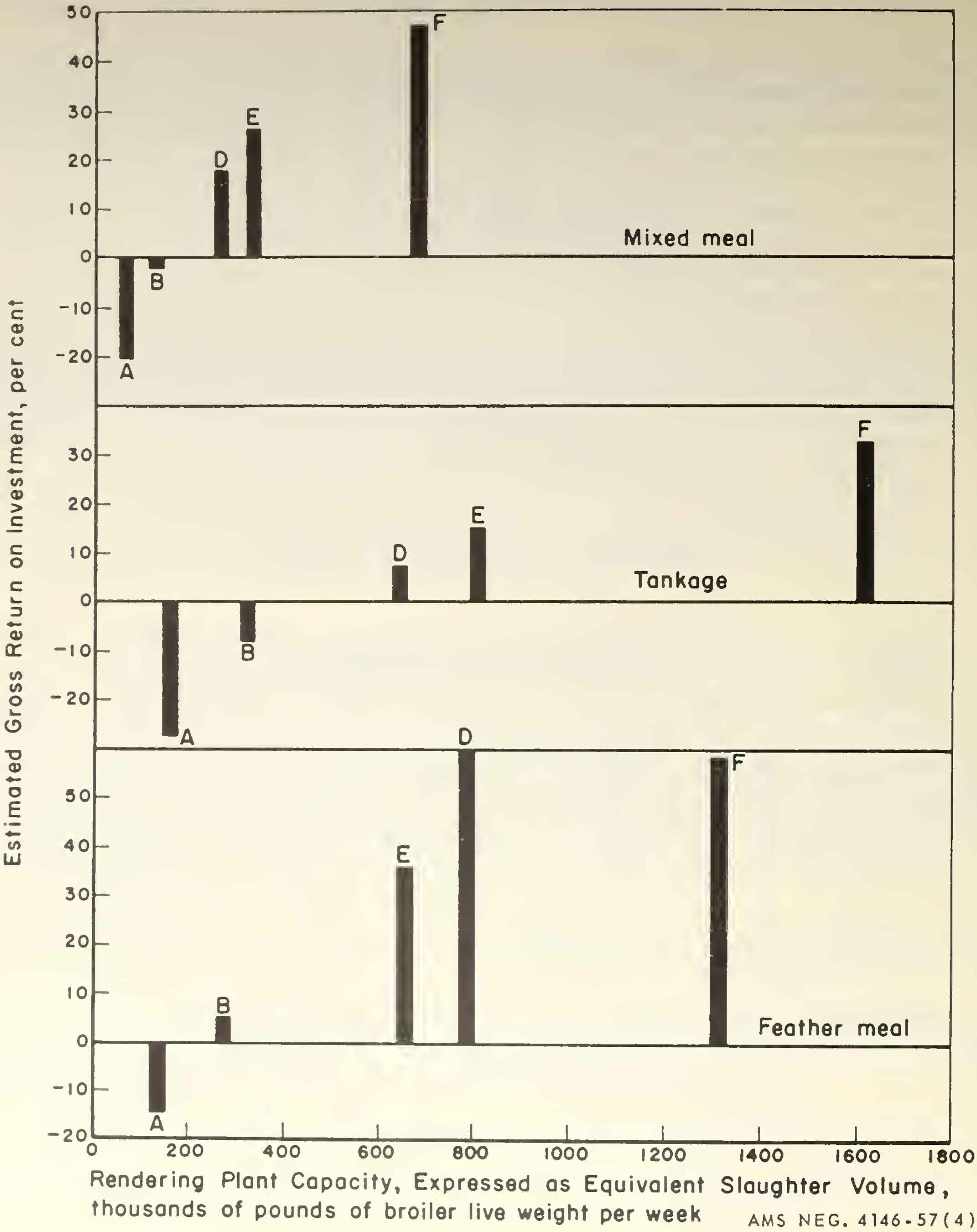

FIGURE 10. ESTIMATED GROSS RETURN ON INVESTMENT FOR FIVE DIFFERENT WASTE PROCESSING PLANTS

The five plants are assumed to be operated at their design capacities for the three different products. Gross return based on estimated profits before Federal income taxes.

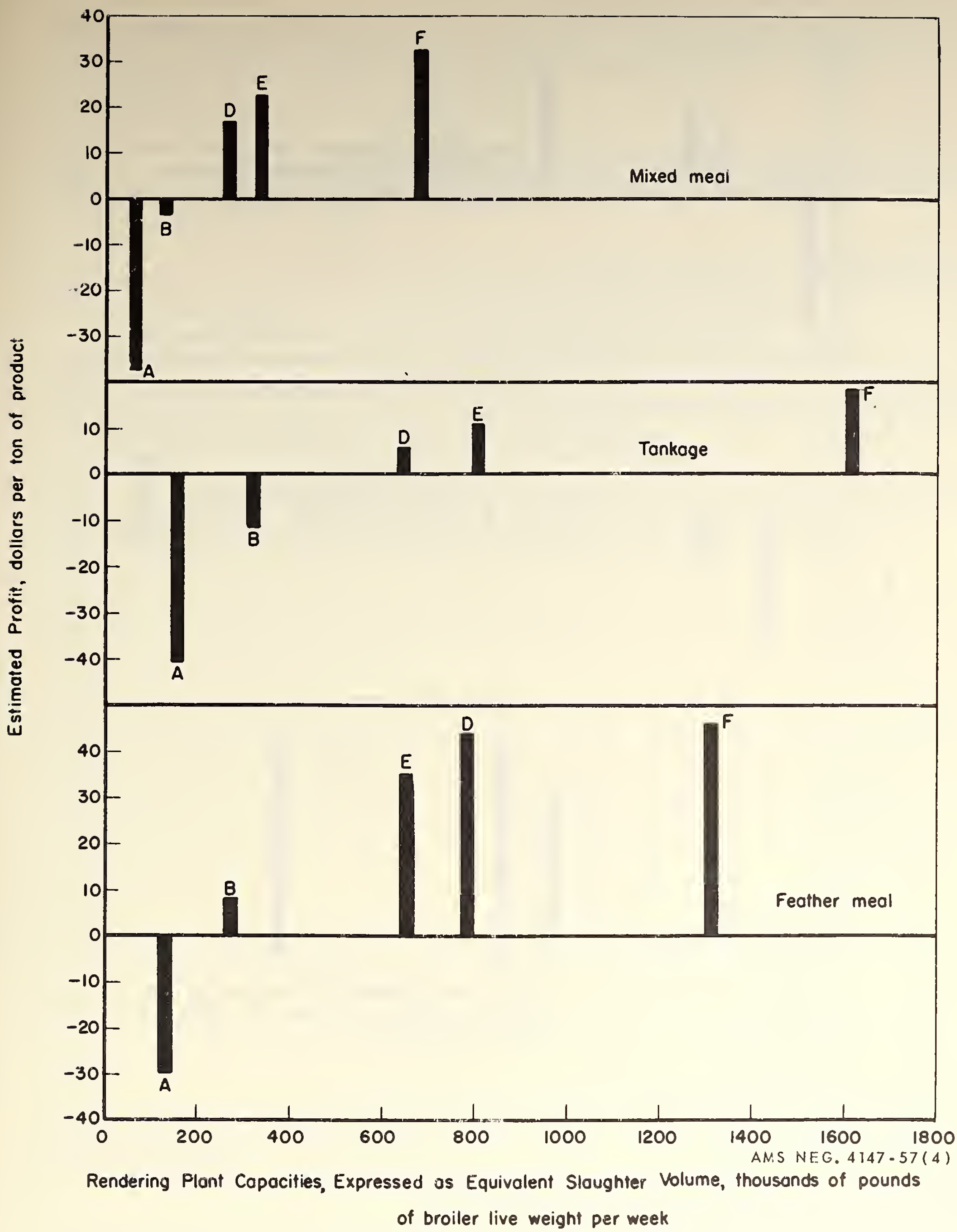

FIGURE 11. ESTIMATED GROSS PROFIT PER TON OF PRODUCT

The five plants are assumed to be operated at their respective design capacities for the three different products. Estimated gross profits are before Federal income taxes.

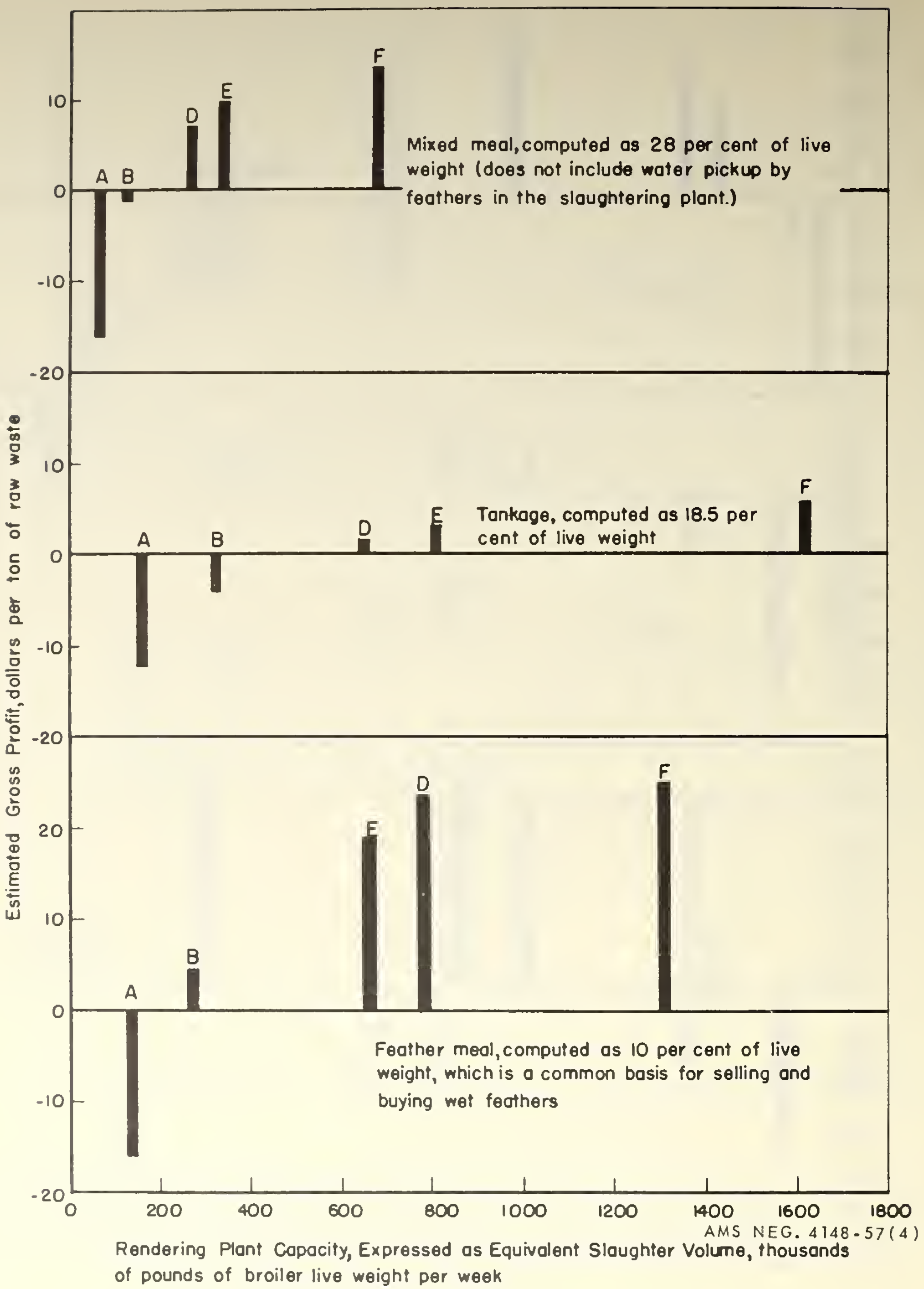

FIGURE 12. ESTIMATED GROSS PROFIT AS RAW WASTE VALUE

The five plants are assumed to be operated at their respective design capacities for the three different products. Estimated gross profits are before Federal income taxes.

(3) At slaughtering volumes in excess of 300, 000 pounds of live weight per week, profitable operation of integrated rendering plants appears possible, with returns on investment becoming fairly attractive when the 500, 000 pound mark is passed.

(4) Extraction of fat, or the production of blood meal, appears impractical at slaughtering volumes below approximately one million pounds live weight per week.

(5) Production of mixed meal from the combined wastes from a slaughtering plant appears to be the most attractive procedure – provided that a market exists or can be developed for this material.

(6) The exact solution to the waste problems of slaughterers in a given region will depend on a number of local factors that should be studied in each case before a final decision is made.

(7) Utilization of a dryer in conjunction with cookers rather than cookers alone can be more profitable in producing feather meal.

APPENDIX A

POULTRY WASTE YIELDS

Broiler and Fowl

Offal

Offal yields reportedly range from 13 to 28 per cent of live weight. Data reported in the literature[1]* indicate that offal yields vary depending on the breed, sex, and weight of the birds. Most of the literature data[1,2,3,4,5] show a trend of decreasing offal yield with increasing weight of birds. Some of the slaughterers and renderers visited believe that offal yield increases with heavier birds because a greater proportion of the heavier birds processed are hens which have a higher fat content. Plant data on broiler processing examined in one specific case indicate that the offal yield decreases as average live weight increases; however, an analysis of the data does not indicate that this trend of lower offal yield with heavier birds is significant. Broiler weights in general vary only from approximately 2.8 to 4.0 pounds, and in specific plants may vary over a still smaller range (e.g., one plant reported variations from 3.2 to 3.9 pounds). Thus with broilers an average yield percentage can be used in most cases without introducing significant errors.

The offal yield data obtained from Plant X and Plant Y reported in Table A-1 are considered to be reasonable average yield values for broilers. These plant yield data agree well with the experimental work by Mitchell[4,5] reported in Column 3 of Table A-1. Column 4 of Table A-1 shows the range of reliable values reported by slaughterers or in the literature and tends to confirm the data reported in Columns 1, 2, and 3. For subsequent calculations in this report, an average broiler offal yield of 18.5 per cent, including 1.0 per cent additional water pick-up, will be used.

* Literature citations refer to list of references, p. 76.

TABLE A-1. SUMMARY OF WASTE YIELDS OF BROILERS

	Plant X	Plant Y	Mitchell[4,5]	Ranges Reported
Offal	17.5	17.5	17.9	15 - 20
Blood	3.0	3.5	3.9	3.2 - 4.2
Feathers	7.0[a]	7.0[a]	7.3	4.8 - 7.5
Total From Birds	27.5	28.0	29.1	
Water With Offal	0	1.0	1.0[a]	
Water With Feathers	15.0[a]	15.0[a]	15.0[a]	
Total From Plant	42.5	44.0	45.1	

(a) These figures were not derived from the data reported in each particular case, but were estimated for the case from other sources of information.

The offal yield data available for fowl were too limited to make an accurate estimate of the average offal yield for all classes of fowl. Slaughterers did report that offal yield from fowl tends to be slightly smaller than that for broilers. For calculation elsewhere in the report, an assumed offal yield from fowl of 18 per cent was assumed. In any case, fowl yields must be actually determined in the plant, because differences arising from the large variations in weight, age, and breed may introduce serious errors when a general average yield is applied to a specific slaughtering plant.

Blood

As shown in Table A-1, a blood yield ranging from 3.2 to 4.2 per cent may be expected. Newell and Schaffner[6] have published data indicating experimental blood yields in the range of 3.8 to 4.2 per cent of live weight. Actual processing plant weights (in Table A-1) show yields of 3.5 per cent of live weight for broilers. It is possible that there is some loss of blood in plant processing that would result in lower yields than are obtained in laboratory experiments. In one case the daily blood yields were compared with the daily live weights (over-all average 3.5 pounds). This comparison indicated that blood yield is smaller with heavier broilers. Analysis of the data showed this trend to be significant, and indicated that blood yield might drop below 3.0 per cent for birds with average live weights greater than four pounds. No other data were found in the literature, or obtained from other slaughterers, which would prove or disprove this isolated observation. For calculations in this report, a blood yield of 3.5 per cent for broilers and 3.0 per cent for fowl was assumed.

Feathers

Very little information is available on feather yields, either in the natural condition on the bird or after scalding. Many plants that render or sell offal for rendering do not dispose of feathers through rendering. Most feathers being rendered are purchased as an arbitrary per cent of live weight and therefore are not weighed at the poultry processing plant. In the work of Mitchell[4,5], the feather yield of Leghorns and Rhode Island Reds ranged from 6.6 to 7.6 per cent, with an average of 7.0 per cent of live weight. Several authors report that New York-dressing shrinks are generally 10 to 11 per cent of live weight.[1,7,8] A New York-dressed bird has only feathers and blood removed. Subtracting an average blood yield of 3.5 per cent gives a feather yield range of 6.5 to 7.5 per cent of live weight. A feather yield of 7.0 per cent was assumed as a reasonable average value for calculations in this report.

The feather yields discussed above apply to the feathers in their natural condition on the bird before scalding. Mitchell[4,5] showed that feathers in their natural state contain an average of 30 per cent moisture. Rendering data on broiler feathers indicated that wet feathers charged to the cooker contain anywhere from 60 to 80 per cent water. From this information one can calculate that wet feather yields range from 12 to 25 per cent of the live weight. These wet feather yields correspond to a pick-up and retention of processing water equivalent to 5 to 18 per cent of the live weight. The majority of information obtained on feather yields indicates that wet feather yield generally will range from 20 to 22 per cent of the live weight (corresponding to a pick-up and retention of 13 to 15 per cent of live weight). For calculations in this report, an average water pick-up of 15 per cent and a wet feather yield of 22 per cent was assumed for broilers. For fowl, an average water pick-up of 13 per cent and a wet feather yield of 20 per cent were assumed for calculations.

Turkey

Turkey offal yields reported by slaughterers ranged from 10 to 15 per cent, with heavy birds such as Broadbreasted Bronz Toms giving the low yield and light birds such as Beltsvilles giving the high yield. For calculations in this report, an offal yield of 12.5 per cent was assumed for turkeys weighing about 15 pounds. Offal yields from turkeys are considerably lower than the average offal yield of 18.5 per cent estimated for broilers. The high tankage yield from turkey offal reported by renderers indicates that there is little or no additional water pick-up with turkey offal.

Broadbent and Bean(8) determined that the New York-dressed shrink on four particular breeds of turkeys ranged from 8.8 to 11.4 per cent, with the heavier birds giving the lower New York-dressing shrinks. Thus the blood and feather yield for 8- to 15-pound turkeys is similar to that from broilers. From the limited data available, the lower blood and feather yield from heavy turkeys cannot be assumed to be a general condition. For calculations in this report a blood yield of 3.5 per cent and a feather yield (in natural condition before scalding) of 7.0 per cent was assumed for turkeys. Feather meal yields reported by renderers for turkeys indicate that turkey feathers pick up and retain water from scalding equivalent to 5 to 7 per cent of the live weight. A wet feather yield of 14 per cent (7 per cent natural feathers and 7 per cent additional water) was assumed for calculations in this report.

APPENDIX B

POULTRY BY-PRODUCT YIELDS

Broiler and Fowl

Offal By-Products

Renderers contacted stated that dry-rendered tankage from broiler offal, properly processed, contains from 5 to 10 per cent moisture and from 16 to 24 per cent fat. Tankage yields for broilers were reported to range from 25 to 34 per cent of the cooker charge weight. With the estimated offal yield of 18.5 per cent, tankage yields correspond to 4.6 to 6.3 per cent of the live weight. For this report, a cooker yield of 31.4 per cent and live weight yield of 5.8 per cent were assumed. Assuming an 8 per cent final moisture content, these yields correspond to water contents in the original offal of 68.7 to 77 per cent and original fat contents of 4 to 7 per cent. This range of broiler offal compositions, derived from reported rendering data, is in reasonable agreement with data reported by Mitchell.[4,5] Yields and compositions for the high and low yield examples above are shown in Table B-1. With moisture at 8 per cent and residual fat at 10 per cent, the poultry by-product meal yields are 23.4 to 29.7 per cent of the cooker charge. From the estimated offal yield, these poultry by-product meal yields correspond to 4.34 to 5.5 per cent of live weight. An estimated poultry by-product meal yield of 5.16 per cent and a fat yield of 0.64 per cent of live weight were assumed for this report. The estimated fat yield corresponds to a yield of 11 per cent of the tankage weight. Table B-2 summarizes the yield of by-products derived from broiler offal.

For fowl, tankage yields as high as 54 per cent of the cooker charge have been reported[9]. Renderers reported yields for fowl as low as 28 per cent. Mitchell[4,5] indicates that the fraction of solids in the offal of light and heavy chickens remains reasonably constant; the fraction of water decreases as the fraction of fat increases in heavier chickens. This explains why the tankage yield for heavier birds, especially fat hens, is higher than that of broilers and also why the poultry by-product meal yield for fowl is about the same as that for broilers when the extra fat is extracted. Yields and composition for both a high-yield fowl example and low-yield fowl example, calculated from compositions reported by Mitchell[4,5] are shown in Table B-3. In these two examples, tankage yields are 30.4 and 41.3 per cent of the cooker charge weight. Poultry by-product meal yields are 24.9 and 23.7 per cent. From the assumed offal yield (18 per cent of live weight), the above tankage yields correspond to 5.5 to 7.4 per cent of live weight. The poultry by-product meal yields correspond to 4.26 to 4.5 of live weight. The fat yields of 5.6 and 17.6 per cent of the cooker charge correspond to live-weight yields of 1 to 3.2 per cent. Table B-4 summarizes the yields of by-products derived from fowl offal in the case of fat birds.

Dried Blood

Poultry blood contains on the average 77 to 81 per cent water[10]. Thus, the yield of dried blood, if cooked until bone dry, would be 19 to 23 per cent of the cooker

TABLE B-1. BROILER OFFAL BY-PRODUCT YIELDS AND COMPOSITIONS AT VARIOUS STAGES OF PROCESSING

		High-Yield Offal		Low-Yield Offal	
		Per Cent of Charge	Per Cent of Product	Per Cent of Charge	Per Cent of Product
	Total Charge	100	100	100	100
Initial Offal	Water	69	69	77	77
	Fat	7	7	4	4
	Solids	24	24	19	19
	Cooker Yield	33.7	100	25	100
Yield of Tankage at 8% Moisture	Water	2.7	8.0	2.0	8.0
	Fat	7	20.8	4	16.0
	Solids	24	71.2	19	76.0
	Press Yield	29.7	100	23.4	100
Yield of By-Product Meal at 10% Fat	Water	2.7	9.1	2.0	8.6
	Fat	3.0	10.0	2.4	10.3
	Solids	24	81.9	19.0	81.1

TABLE B-2. BROILER OFFAL BY-PRODUCT YIELDS

	Per Cent of		
	Live Weight	Charge Weight	Tankage Weight
Cooker Charge	18.5	100	--
Tankage	5.8	31.4	100
Poultry By-Product Meal	5.16	27.9	89
Fat	0.64	3.5	11

TABLE B-3. FOWL OFFAL BY-PRODUCT YIELDS AND COMPOSITIONS AT VARIOUS STAGES OF PROCESSING

		High-Yield Offal		Low-Yield Offal	
		Per Cent of Charge	Per Cent of Product	Per Cent of Charge	Per Cent of Product
	Total Charge	100	100	100	100
Initial Offal	Water	62	62	72	72
	Fat	20	20	8	8
	Solids	18	18	20	20
	Cooker Yield	41.3	100	30.4	100
Yield of Tankage at 8% Moisture	Water	3.3	8.0	2.4	8.0
	Fat	20.0	48.4	8.0	26.3
	Solids	18.0	43.6	20.0	65.8
	Press Yield	23.7	100	24.9	100
Yield of By-Product Meal at 10% Fat	Water	3.3	13.9	2.4	9.6
	Fat	2.4	10.1	2.5	10.0
	Solids	18.0	76.0	20.0	80.4

TABLE B-4. FOWL OFFAL BY-PRODUCT YIELDS

	Per Cent of		
	Live Weight	Charge Weight	Tankage Weight
Cooker Charge	18.0	100	--
Tankage	7.44	41.3	100
Poultry By-Product Meal	4.27	23.7	57.3
Fat	3.17	17.6	42.7

charge. Renderers reported lower dried blood yields, ranging from 5 to 12.5 per cent of the cooker charge. Some of them also reported that those low yields were obtained because the blood had been diluted at the poultry slaughtering plant. For calculations in this report a cooker yield for dried blood (assuming 8 per cent moisture) of 22.2 per cent was assumed for all poultry blood. This corresponds to a live weight yield of 0.78 per cent in the case of broilers and turkeys and 0.67 per cent in the case of fowl.

Feather Meal

Feather meal yields have been reported as ranging between 20 and 40 per cent of cooker charge(9). The most commonly quoted yield figure is 25 per cent of the charge weight(9). For this report a 25 per cent yield on the cooker charge was assumed. With the estimated wet feather yield (22 per cent of live weight), this cooker yield corresponds to a yield of 5.5 per cent of the live weight.

Actually, feathers in their natural condition contain about 30 per cent moisture. In other words, 100 pounds of the natural feathers contain 70 pounds solids and yield 78 per cent of a feather meal containing 10 per cent moisture. This 100 pounds of feathers during processing picks up an additional 214 pounds of water which must be driven off in the cooker. Other methods for removing part of this additional water (such as centrifuging) have been considered, but cooking wet feathers as received from the processing plant is the common practice.

Turkey

From the limited data available on the separate rendering of turkey wastes, turkey offal is estimated to yield 40 per cent tankage. Although no data are available to prove it, it is believed that this yield varies with the type and size of bird slaughtered. Assuming that turkeys on the average yield 12.5 per cent of live weight as offal, the tankage yield would be 5.0 per cent of the live weight. This tankage yield is only slightly less than the average yield of 5.8 per cent assumed for broilers. Since this turkey tankage yield is based on very limited data, it should not be automatically considered as the best average value for turkeys. The fat content of turkey tankage is reported to be about 25 per cent, which is slightly higher than the average of 20 per cent taken for broiler tankage. The residual fat after pressing is about the same in turkey tankage as in broiler or fowl tankage, so that a greater fat yield and a lower solids yield is obtained. Table B-5 summarizes the average yield figures that were assumed for turkey offal.

TABLE B-5. TURKEY OFFAL BY-PRODUCT YIELDS

	Per Cent of		
	Live Weight	Charge Weight	Tankage Weight
Cooker Charge	12.5	100	--
Tankage Yield	5.0	40	100
Poultry By-Product Meal Yield	4.16	33.3	83.4
Fat Yield	0.84	6.7	16.6

Yield of turkey blood should be about the same as that for broiler blood. Turkey feathers, however, are reported to absorb less additional water and give a higher cooker yield than chicken feathers. Cooker yields of feather meal are reported to be around 42 per cent, and this figure has been used for calculation in this report. Based on the reported wet feather yields, ranging from 12 to 14 per cent of live weight, a feather meal yield of 5 to 5.9 per cent of live weight would be expected, with an average of 5.5 per cent. This turkey feather meal yield is about the same assumed for chicken feathers.

Available data indicate that by-product yields based on live weight are very similar to chicken by-product yields. Even though these ultimate yields based on live weight are similar, cooker yields are higher. This indicates that rendering turkey wastes will be more profitable than rendering broiler or fowl wastes, because a greater by-product output will be obtained in the same plant and the cost of evaporating water per ton of by-product will be less.

APPENDIX C

POULTRY BY-PRODUCTS QUALITY AND MARKETABILITY

Introduction

Poultry by-products have been used primarily as feed supplements and fertilizers. Since the price offered for the nitrogen of feed stuffs is higher than that for fertilizers, feed supplements provide the most lucrative market for poultry by-products. Furthermore, since chemical fertilizer can generally be prepared at less cost per unit of nitrogen than natural organic fertilizer such as poultry by-products, fertilizers are not a promising potential market for poultry by-products. There has been some demand for natural organic material as conditioners which improve the caking resistance of the chemical fertilizers. However, with the increased use of granulation processes to reduce fertilizer caking, the market for natural organic materials as fertilizer conditioners will probably decrease.

Other uses for poultry by-products have been considered, but as yet these outlets have not appeared promising. Feather meal has been claimed to be a substitute for hoof meal as a plaster retarder. Dried feathers have been used as fillers for pillows, mattresses, etc; however, synthetic materials, because of their consumer appeal, have virtually eliminated this outlet for feathers. The use of dried and ground feathers as a fibrous filler for such things as wall board and brake linings has not proved economical. Processes have been worked out to dissolve feathers and regenerate a protein fiber that might be used in the textile industry[11]. However, protein fiber regeneration has not, as yet, opened up as a market for feathers. There has been some use of animal by-products as a source for manufacturing chemically pure proteins and protein fractions, but this use does not provide an extensive market.

Feed supplements such as fish meal, meat scraps, and soybean meal are commonly used to supply as much as 10 per cent of the protein in a feed ration. Poultry by-product meal has a feed value similar to that of meat scraps. Compared to fish meal, both are considered deficient in the amino acid, methionine. Synthetic methionine can, however, be added to a feed ration. Feather meal by itself has been reported not to give sufficient growth response compared to its protein content. The superiority of meat scraps (and poultry by-products meal) to feather meal and also dried blood, where used separately, may be connected with the fraction of total protein that is digestible. Nearly all of the protein in meat scraps is digestible, about 75 per cent of feather meal protein is digestible, and about 50 per cent of dried blood protein is digestible. Feather meal and dried blood complement soybean meal, meat scraps, and each other to give adequate growth response when used in combination in the feed ration.[12] Some investigators have found an additional growth response above that to be expected from the protein level when feather meal is used in combination with other feed supplements.[12] They have speculated that feather meal contains an unidentified growth factor perhaps similar to Vitamin B_{12}. The value of dried blood when used with other supplements has been attributed to its high lysine content; meat scrap type supplements may often be deficient in this amino acid.[13, 14]

Table C-1 shows the range of compositions reported for poultry by-products.

TABLE C-1. COMPOSITIONS OF POULTRY BY-PRODUCTS

	Per Cent of Product[a]			
	Feather Meal	Dried Blood	Poultry By-Product Meal	Tankage
Protein	75-90(85)	75-85(80)	50-60(55)	45-55(50)
Moisture	5-15(8)	5-15(8)	5-15(8)	5-12(8)
Fat	2-4(3)	0.8-1.2(1.0)	6-15(10)	16-25(20)
Fiber and Ash	2-7(4)	8-14(11)	25-30(27)	20-25(22)

(a) Ranges reported are shown, with the average values assumed for calculations in this report in parentheses.

Fats extracted from poultry tankage have a number of uses that vary in value. Prices have been quoted that range from 2 to 8 cents per pound. As far as the ultimate use is concerned, inedible uses such as soap making bring lower prices than edible uses such as fat-fortifying of feeds. The price obtained for a fat depends on its quality as well as the end use; quality is often judged by the free fatty acid content of the fat. Free fatty acids are formed by oxidation and hydrolysis of unsaturated glycerides contained in the fat. These fatty acids and other oxidation products are volatile and have distinct objectionable odors, which indicate the fat has become rancid. Poultry fat is more prone to oxidize and become rancid than other fats because it has a greater content of unsaturated glycerides. The addition of a stabilizer reduces the tendency of fats to oxidize and thus become rancid. If a stabilizer is added soon enough, poultry fat is acceptable for fat-fortifying feeds. Butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), propylgallate, and 6-ethoxy-1,2-dihydro-2,2,4-trimethylquinoline* are chemicals commonly used for fat stabilization. Citric acid and propylene glycol may be used with one or more of the above chemicals.

The feed industry has in the past preferred animal by-products with low fat contents, for three reasons. First, a lower fat content makes the material more free-flowing, which is desirable in feed compounding. Second, the less fat present the less chance of objectionable rancidity developing in the feed. Third, fats in the past were not believed to add any nutritional value. Today feed manufacturers are accepting the fact that fat does have nutritional value in their feeds, that it reduces the dusting problem, and that the fat content can be stabilized in the rendering plant. Although they still want free-flowing material, some are now buying meat scraps and poultry by-product meal on a guaranteed fat content basis. Many are buying additional fat to add at the latter stages of feed formulation. Thus the use of fats for fat-fortifying feeds is a promising market.

Effect of Collection and Storage

The quality of poultry by-products is very definitely related to the freshness of the waste when it is cooked. This quality is not something that can be readily measured and attributed to one factor or another. The development of rancidity in the fat content is one factor. Another factor is formation of undesirable and sometimes toxic components during putrefaction of the protein content. Putrefaction is aided by the bacteria and enzymes in the waste, and is very rapid during warm humid weather.

Renderers prefer that the waste they charge to the cooker in warm weather be less than 6 hours old; the waste should never be more than one day old. During cold weather, freshness is not as serious a problem, although the natural warmth of the waste as it comes from poultry will cause some putrefaction in any case. The higher the temperature (short of rapidly dehydrating the material in the cooker) and the humidity, the greater the freshness problem. If only half-day old (or less) waste is processed, a low-acid fat and a high quality by-product meal can be produced. As the material gets older than one-half day, greater amounts of stabilizer will have to be used.

Effect of Operating Procedures

Cooking

The quality of poultry by-products can be influenced during cooking by either physical or chemical means. Elevated temperature and prolonged cooking time promote chemical changes, especially oxidation of the fat. One poultry processor is marketing an edible chicken fat for human consumption by vacuum rendering at temperatures below 130 F.[15] One cooker manufacturer recommends that the temperature during cooking definitely not be allowed to go over 250 F. One renderer maintains his fat quality by loading his cookers so that the cooking can be accomplished in no more than 2 hours. The fact that poultry offal usually takes longer to cook than wastes from other animals makes it more difficult to obtain a high-quality fat from poultry offal. It has been claimed that partially cooking poultry offal in a cooker and completing the drying in a separate dryer will give better fat quality. It is also claimed that higher temperatures cause the by-product meal to have a lower digestibility and a lower nutritive value.[16] Studies on flame drying and steam-tube drying of fish meal, when presumably the flame drying caused higher temperature in the meal, did not show any difference in digestibility of the fish meal.[17, 18] Overcooking to the point of burning the tankage and forming a rubbery carbonized product with low feed value is possible if cooking temperatures are not controlled. Overcooking will also reduce the yield of fat during subsequent pressing.

Physical changes in quality result from agitation and over-cooking. Some renderers feel that less fines are produced (which subsequently press out with the fat) if the agitator speed is kept below 20 rpm instead of the commonly used 38 rpm. For otherwise identical batches, the lower agitator speed will increase the required cooking time. Some renderers feel that overcooking and making the tankage too dry causes more fines than the higher agitating speeds do. Experimental study in the rendering plant is required to determine what specific operating procedure will give an optimum production rate and an optimum quality of fat in respect to both minimum fat oxidation and fine solid particle content. In summary, one can qualitatively state that low cooking temperatures, low agitation speed, and short cooking time will tend to give a better quality product. These requirements are contradictory, however, and a suitable set of compromise conditions must be selected for commercial operation.

Final moisture content is important in that it indicates whether the cooker batch is overcooked or undercooked. Eight per cent moisture in the tankage is usually assumed to be the optimum moisture content. The effect of overcooking on product quality is discussed above. The effect of undercooking results in too much moisture and poor pressing characteristics of the tankage. If the tankage is too wet, the solids tend to flow out of the press with the fat.

Drying

Separate dryers are used to increase production by reducing the time the tankage must be held in the cookers. Generally the tankage can be removed from the cookers in half the time normally required if separate drying is used. The use of separate dryers is quite common for feather meal. Separate drying has been used for processing tankage[19], but this is not common. Dried blood can be finished off in a dryer, if desired.

Use of a separate dryer probably reduces the agitation and grinding effect on the tankage. One renderer reported that separate drying reduced the amount of fines in the fat and also resulted in a press cake with better texture.

It is possible to overheat the tankage in a dryer. In one case of drying feather meal in a flame dryer, the drying temperature had to be lowered to reduce the obnoxious odors given off. When the material exit temperature was reduced from 160 to 170 F. down to 140 to 150 F., the amount and character of the odor was reduced and the color of the feather meal became lighter, indicating better quality.[20] Users of steam-tube dryers report tankage outlet temperatures from 160 to 180 F. with satisfactory results.[19] Steam-tube dryer manufacturers have stated that an applied steam pressure of over 60 psi, which corresponds to a steam temperature of over 300 F., will tend to damage the feather meal product and produce obnoxious odors.[21]

Fat Extraction

Storage of tankage before pressing to extract fat will reduce the quality of the by-product meal and fat. The same phenomenon is involved here as is involved in decreased quality due to storage of raw offal before cooking. The fat present in the tankage tends to be oxidized and become rancid. If a suitable stabilizer (antioxidant) has been added during the cooking, the problem of rancidity developing during storage of the tankage before pressing is reduced. A high moisture content of the tankage promotes hydrolysis and thus increases the chances of spoilage.

The pressing operation itself does not alter the quality of fat significantly, unless the equipment is not kept clean. Fines and moisture in the fat are primarily influenced by the cooking operation. However, the pressing operation can influence the quality of the by-product meal. If the pressing is not properly operated, the by-product meal can have too high a fat content, which may promote spoilage of the meal and reduce the free-flowing qualities of the meal. A high fat content will also make the subsequent grinding operation more difficult.

APPENDIX D

EQUIPMENT AND CAPITAL

Equipment Description and Costs

Rendering installations vary from small plants of one or two cookers, plus a boiler to supply steam, to large plants containing five or more cookers, several boilers, several presses, a dryer, grinding and bagging equipment, and conveying equipment. The first installation above might handle the poultry waste from a broiler-processing plant handling 200,000 to 300,000 pounds of live weight per week. The second example would require poultry waste from about 1.0 to 1.5 million pounds live weight per week. This section discusses various units of equipment, their operation, and their cost. Table D-1 summarizes the nature of the plants visited.

Cookers

Inedible animal wastes at one time were rendered in digester tanks where the waste charge was cooked with live steam. This process yielded three products: free fat, water, and cracklings. The cracklings, when pressed and ground, were called digester tankage or wet-rendered tankage. This wet-rendering process has been largely replaced by the dry-rendering process where the charge is heated through contact with a steam-heated jacket. Agitation is used in jacketed cookers to promote better heat transfer and to prevent burning. Most of the water in the waste charge is evaporated, resulting in a product consisting of almost dry solids and fat. These dry-rendering cookers are also called horizontal melters.

Cookers currently available in the United States vary in nominal size from a 2-foot diameter and 6-foot length to a 6-foot diameter and 12-foot length. Table D-2 summarizes the data obtained from seven manufacturers of cookers and other rendering equipment.

The prices for 4 x 7 and 5 x 12 cookers are summarized in Table D-3, with motor and motor-starter prices added to obtain a total cooker cost. Boiler prices are not included here but discussed later under "auxiliary equipment," since one boiler may serve more than one cooker as well as other equipment in addition to cookers.

Of the cookers observed at seven plants processing poultry wastes, all were either 4 x 7 or 5 x 12 cookers. Most of the 5 x 12 cookers observed were used to process feathers and were operated under internal pressure. Most of the 4 x 7 cookers observed were capable of cooking the charge under pressure but were operated at atmospheric pressure, processing offal and/or blood.

TABLE D-1. SUMMARY OF THE TYPES OF RENDERING PLANT OPERATIONS VISITED

Type of equipment in plants	One plant with only two 4 x 7 cookers.
	One plant with four 4 x 7 cookers, curb press, and grinder.
	One plant with five 4 x 7 cookers, curb press, and grinder.
	One plant with four 5 x 12 cookers, three steam-tube dryers, and grinder.
	One plant with seven 5 x 12 cookers, three curb presses, and grinder.
	One plant with five 5 x 12 cookers, curb press, and grinder.
	One plant with four 5 x 12 cookers, direct-fired dryer, and grinder
	One plant with two 5 x 12 cookers, fat extraction equipment, and grinder.
By-products obtained	One plant producing only tankage and dried blood.
	Two plants producing poultry by-product meal and fat.
	One plant producing poultry by-product meal, fat, and dried blood.
	One plant producing feather meal.
	One plant producing poultry by-product meal, fat, and feather meal.
	One plant producing poultry by-product meal, fat, feather meal, and dried blood.
	One plant producing mixed meal and feather meal.

TABLE D-2. APPROXIMATE COOKER SPECIFICATIONS

Nominal Cooker Size Dia. x Length, feet	Approximate Internal Volume, cubic feet	Load Rating[a], thousand pounds water	Approximate Agitator Motor Power[b], horsepower	Approximate Boiler Power[c], boiler horsepower	Approximate Price[d], dollars
2 x 6	10	--	3	--	3, 600
3 x 4[e]	20	--	5	10 - 15	1, 600[e]
4 x 4	40	--	10	30	4, 200
4 x 7	70 - 85	4 - 5	10 - 25	25 - 35	6, 000 - 6, 200
4 x 7[e]	65	--	10	25 - 30	3, 100[e]
4 x 9[e]	80	--	15	35	3, 800[e]
4 x 10	100 - 130	6 - 7	20 - 25	35 - 50	6, 700 - 7, 500
5 x 10	160	8	20 - 25	45 - 50	7, 500
5 x 12	200 - 220	10	30	50 - 75	7, 700 - 8, 500
5 x 16	250	--	30	--	12, 000
6 x 9	230	--	40	80	9, 000
6 x 12	350	--	40	--	--

(a) Load ratings are arbitrary ratings. Manufacturers recommend charging the cooker to 60-80 per cent of the total volume with offal or blood.

(b) Agitator motor power should be increased for cookers processing feathers. Manufacturers recommend 20-50 per cent more power.

(c) Boiler horsepower requirements are reduced where more than one cooker is operated. The load on the boiler is greatest at the beginning of a cook. With two or more cookers, cooker start-ups can be staggered to reduce peak-load steam demand.

(d) Motors and boiler are not included. Other auxiliaries such as valves and pressure gages are included.

(e) These prices apply to cookers not built to stand any internal pressure. The other cookers listed are built for a 45 psig internal pressure in addition to a 90 psig jacket pressure.

TABLE D-3. SUMMARY OF PRINCIPAL COOKER COSTS

Nominal Cooker Size Diameter x Length, feet	Estimated Average Internal Volume, cubic feet	Estimated Price, dollars	Estimated Average Motor Size, horsepower	Estimated Motor[a] and Starter Cost, dollars	Estimated Total Cost, dollars
4 x 7	80	6, 100	15	340[b]	6, 440
			25	570[c]	6, 670
5 x 12	210	8, 100	30	600[b]	8, 700
			50	1, 000[c]	9, 100

(a) Open construction, three phase, 220 volt.
(b) Smaller motor for offal and blood only with normal starting torque.
(c) Larger motor for cookers processing feathers with high starting torque.

Cookers are never completely filled because some space is needed to allow the steam generated from the charge to pass freely out the exhaust opening at the top of the cooker. Also, when the cooker is completely filled, the generated steam tends to carry part of the charge out with it, which causes problems in the exhaust piping. Information obtained from plant visits indicates that cookers are charged from 50 per cent full to as much as 80 per cent full with offal or blood. For 4 x 7 cookers, an average charge weight of 3, 000 pounds of offal or blood is common. For 5 x 12 cookers, an average charge weight of 7, 500 pounds of offal or blood is normal. Practice varies from plant to plant. Some operators will load the cookers lightly to reduce the cooking time per charge and improve the quality of the fat. Other operators will load the cookers heavily so that the entire truckload can be cooked immediately. With feathers, the cookers are actually filled to a higher level, but because of the lower density of wet feathers (compared with offal), about the same weight is charged. Most operators experiment to find the number of barrels of feathers that can be handled in one cooker charge; approximately 30 barrels have been reported for 5 x 12 cookers. Table D-4 shows the live weight of broilers, fowl, and turkey that correspond to average loads of particular wastes in a 4 x 7 and in a 5 x 12 cooker.

The cooking times reported or recommended ranged from 1-1/2 hours for feathers which will be transferred from the cooker to a dryer, to 12 hours for blood that has caked on the inside of a cooker shell. Table D-5 shows the range of cooking times and a reasonable average cooking time for the three different raw materials and two sizes of cookers. The end point of a "cook" is commonly determined by removing a sample from the sample cock and rubbing it between the fingers to feel grittiness, although experienced cooker operators can often judge the time that will be required when they charge the cooker. Rendering equipment manufacturers recently have been offering a moisture indicator which, after being set during a trial cook, sounds an alarm when the correct moisture content is reached. The cooking times

TABLE D-4. LIVE WEIGHT AND YIELD RELATIONS TO STANDARD COOKER LOADS

Charge	Percentage of Live Weight			Pounds of Live Weight and Yield Weight Corresponding to Standard Cooker Charge					
				4 x 7 (3,000-lb charge)			5 x 12 (7,500-lb charge)		
	Broiler	Fowl	Turkey	Broiler	Fowl	Turkey	Broiler	Fowl	Turkey
Offal	18.5	18.0	12.5	16,200	16,700	24,000	40,500	41,700	60,000
Blood	3.5	3.0	3.5	85,700	100,000	85,700	214,000	250,000	214,000
Feathers	22.0	20.0	14.0	13,600	15,000	21,400	34,100	37,500	53,500
Combined waste	44.0	41.0	30.0	6,800	7,300	10,000	17,000	18,300	25,000
Yields									
Tankage	5.8	7.44	5.0	930	1,240	1,200	2 320	3,100	3,000
Dried blood	0.78	0.67	0.78	660	670	660	1,650	1,680	1,650
Feather meal	5.5	5.50	5.9	750	825	1,230	1,880	2,060	3,080
Combined waste	12.1	--	11.7	820	--	1,150	2,050	--	2,880

TABLE D-5. COOKING TIMES FOR POULTRY WASTES PROCESSED COMPLETELY IN COOKER

	Hours			
	4 x 7 Cooker		5 x 12 Cooker	
	Reported Range	Estimated[a] Average	Reported Range	Estimated[a] Average
Offal	3.5 – 6	4.5	4 – 8	5.5
Blood	4 – 9[b]	5.5	5 – 12[b]	6.5
Feathers[c]	--	5.0	4 – 9.5[b]	6.0

(a) These cooking times assume that serious caking is not allowed to occur in the cooker and that cookers are loaded to 3,000 and 7,500 pounds, respectively.

(b) Longer time probably shows effect of caking on shell during cooking.

(c) Feathers must be held under a pressure 30 to 40 pounds per square inch for approximately 30 minutes to break down the feather structure unless lime is used to facilitate this breakdown.

required to obtain a material that can be transferred to a separate dryer are reported in Table D-6.

TABLE D-6. COOKING TIMES FOR POULTRY WASTES TO BE FINISHED OFF IN SEPARATE DRYER

	Hours	
	4 x 7 Cooker	5 x 12 Cooker
Feathers	1 – 2	1 – 2
Offal	2 – 3	3 – 4
Blood	3 – 4	4 – 5

These times correspond to approximate discharge moisture contents of 35 to 50 per cent. Cooker operators report that partial processing in the cooker reduces the tendency for caking to occur on the shell. One operator overcomes blood caking by removing partially processed blood after 3 or 4 hours, spreading it on the floor to cool, and then returning it to the cooker to complete the drying. Another operator reported that cooking mixtures of the three wastes (instead of cooking them separately) is preferable because it reduces caking tendencies. The caking of blood can be overcome by adding cattle bones to the cooker; additions comprising up to 10 per cent of the entire charge have been reported.

An internal pressure of 30 to 40 pounds per square inch (psi) for 30 to 60 minutes is used to speed up the breakdown of the feather structure; this process is patented[22]. This pressure must be let down slowly (about 1 psi per minute) to prevent blowing the charge out of the exhaust opening. Reports have been received that the cooker can be operated at atmospheric pressure; additional water must be added to the feather charge to allow the charge to be heated for a much longer time at the lower temperature attained. Lime can be added to the feather charge (50 pounds per ton of wet feathers) to speed up the cooking at atmospheric pressure. It has been reported that certain amino acids and vitamins are reduced in lime-treated feather meal. At present, feathers are mostly cooked under pressure. Blood and offal are not cooked under pressure because the higher temperature under these conditions leads to excessive physical breakdown of the material. The resulting fines may later be pressed out with the fat, thus lowering its quality.

Agitator (paddle) speeds, used in rendering, range from 18 rpm to 38 rpm. Increasing the agitator speed tends to reduce cooking time. In some cases, increasing the speed from 22 to 38 rpm has reportedly reduced the cooking time by as much as 30 per cent. Increasing the agitator speed is limited because power requirements are increased. For blood, an agitator speed of 21 rpm was recommended, with 27 rpm stated as a maximum. For offal, an agitator speed of 38 rpm is commonly used. For feathers, a speed of 25 rpm is common.

Steam pressures in the cooker jacket were reported to range from 50 to 100 psi, which corresponds to a temperature range of 298 to 338 F. Most of the jacket pressures reported were in the range of 60 to 80 psi. Usually higher jacket pressures and temperatures promote faster heat transfer and shorter cooking time. However, high jacket temperatures may cause some local overheating and possibly caking of the material on the cooker shell, especially where the agitator speed is low. Any caking on the cooker shell will increase the resistance to heat flow and thus result in longer cooking times. Each operator must, through experience, determine the optimum jacket pressure and temperature for the particular material and agitator speed being used. In one case of offal processing, a jacket pressure of about 70 psi for the beginning and 40 psi for the finish was recommended. Some operators judge the end point of the cook by the temperature of the charge itself. A range of final temperatures of the charge of 225 to 275 F was reported for offal.

Internal pressures reported for the initial cooking of feathers ranged from 30 to 40 psi. This internal pressure is maintained for 30 minutes to 1 hour. Many of the cookers have condensers connected to the exhaust pipe to condense the waste steam from the charge and reduce the amount of odor discharged into the air. These units are usually barometric condensers which, in addition to reducing odor, tend to pull a vacuum on the cooker. Pulling a vacuum on the cooker will increase the rate of steam removal from the cooker charge and thus tend to shorten cooking time.

There are two methods of cooking blood in addition to charging the cooker with raw blood and cooking until dry. In one method, raw blood is pumped into the cooker in batches of about 100 gallons every 30 minutes. A total of thirteen batches (11, 000 pounds) can be dried in approximately the same time that one charge of 7, 500 pounds can be dried in a 5 x 12 cooker. This increment method of drying blood increases production about 50 per cent, but labor is increased too. In the other method, the raw blood is first coagulated in a tank fitted with steam coils. Coagulation separates the blood into a semi-solid portion (called curds or coagulate) and a liquid portion (called a serum). The coagulate is retained in the tank while the serum is drained off into a sewer. About 50 per cent of the water in the raw blood is removed by this operation. Without coagulating, 100 pounds of raw blood yield 22 pounds of dried blood by the evaporation of 78 pounds of water. With coagulation, the cooker yields approximately 17 pounds of dried blood (approximately 5 pounds of solids remain in the serum) by evaporation of only 33 pounds of water. However, this method can cause severe caking problems. If the cooker is too hot when the coagulate is charged, it will tend to gum up worse than the raw blood would.

Dryers

Drying equipment is being used in some of the larger rendering plants. Where the planned production is sufficient, reducing the number of cookers by installing a dryer may be more economical than installing only cookers. With proper design and operation, the maintenance cost is no greater, and labor cost per ton of product may be substantially reduced. Fixed charges per ton of product may also be reduced because the fixed capital for a cooker-dryer combination can be less per ton of product than that for an installation comprising only cookers. One other advantage of the cooker-dryer combination is that a better quality product may be obtained since the dryer can be operated to give gentler agitation, which produces fewer fines and a lower final drying temperature which may improve fat quality where offal is being processed.

There are two types of dryers commonly used: rotary steam-tube and rotary direct-fired dryers. The steam-tube dryer gives constant temperatures over wide ranges of throughput by controlling the steam pressure in the tubes. The steam-tube dryer can cause product damage if the steam pressure in the tubes is set too high in efforts to increase drying rate. The temperature of the material being dried is commonly controlled by admitting air at the discharge end, which tends to cool the material that has been dried and sweep through the dryer to the feed end, picking up the moisture as it is evaporated from the material.

The rotary direct-fired dryer (the type used widely for alfalfa drying) usually can be installed at less initial cost than a steam-tube dryer of the same capacity. The rotary direct-fired dryer requires careful operation and control of the temperature; otherwise, local overheating by the hot combustion gases can severely degrade the quality of product and produce a bad odor.

Eight of the renderers contacted used dryers; four used rotary steam-tube dryers, and four used rotary direct-fired dryers. Prices quoted on steam-tube dryers varied from $15, 000 to $25, 000, equivalent to a first cost of about $8 to $22 per pound of water evaporated per hour. The initial costs of two direct-fired dryers were $16, 000 and $28, 000 which, with the respective water evaporation capacities of 5, 000 and 7, 500 pounds per hour, gave a cost of $3 to $4 per pound of water evaporated per hour. Thus, the initial cost of a direct-fired dryer (on the basis of cost per pound of water evaporated) is considerably lower than the cost of a steam-tube dryer of the same capacity.

One manufacturer has worked out the relationship between steam-tube dryers and 5 x 12 cookers and found that approximately 500 square feet of heated surface in a steam-tube dryer per 5 x 12 cooker gives the proper balance of drying rates between cooker and dryer. Depending on the type and exact specifications, a dryer of this size could cost from $4,000 to $7,000. The corresponding direct-fired design was estimated to cost $3,000. Dryer costs for different cooker combinations are estimated in Table D-7. For a 500 square-foot steam-tube dryer, additional boiler capacity of approximately 20 boiler horsepower is required.

Steam-tube dryers use tube pressures ranging from 60 psi to 100 psi, which corresponds to a temperature range of 300 to 340 F. The product carries out at a much lower temperature; tankage and feather-meal temperatures out of the dryer at between 140 and 180 F were reported. Direct-fired dryers use combustion gas temperatures as high as 1,800 F(*) and discharge material at about 150 F. The dryers normally receive as feed material either partially processed offal or feathers with 40 to 50 per cent moisture and dry it to 8 per cent moisture.

Steam-tube dryers and direct-fired dryers have been used on both partially processed feathers and offal. Blood has been dried experimentally in a dryer alone by recycling part of the dried product and mixing it with the raw blood to obtain a satisfactory material for feeding into the dryer. This practice has not been commercially adopted as yet.

TABLE D-7. DRYER COSTS FOR DIFFERENT COOKER ARRANGEMENTS

Cookers	Steam-Tube Dryer: Area of Heated Surface, sq ft	Steam-Tube Dryer: Estimated Cost, dollars	Direct-Fired Dryer: Water Evaporated, pounds per hour	Direct-Fired Dryer: Estimated Cost, dollars
2 - 4 x 7 1 - 5 x 12	500	5,000	575	3,000
4 - 4 x 7 2 - 5 x 12	1,000	9,500	1,150	5,500
6 - 4 x 7 3 - 5 x 12	1,500	14,000	1,730	8,000
4 - 5 x 12	2,000	18,500	2,300	10,000
5 - 5 x 12	2,500	23,000	2,880	12,000

*The fact that these high temperatures exist only at the inlet where the feed is wet explains why it does not burn the product.

Presses

The fat content of feather meal and dried blood is below the extraction limit of press equipment. These materials are not put through presses but go directly to a grinder for final processing. Offal does contain sufficient fat so that it is commonly pressed to reduce the fat content to retard spoilage, to obtain better grinding characteristics, and to obtain another salable by-product. Some large rendering installations are equipped with solvent extraction equipment for removing the fat, but such installations are not likely to be profitable in smaller rendering plants processing poultry wastes exclusively.

There are two types of presses used for extracting fat from tankage: screw presses and curb presses (also called cage presses and hydraulic presses). Of ten rendering operations studied, five used curb presses, two used screw presses, one used solvent extraction, and three did not press. Of the three not pressing, one sold tankage to another renderer who pressed and ground the material, one processed only feathers, and the other cooked a mixture of offal and feathers which had a low enough fat content that it did not have to be pressed before grinding.

Curb presses rated from 150 tons to 1100 tons are available. In the instances observed, 300-ton and 600-ton presses were used. Table D-8 presents a summary of press capacity and cost data.

Curb presses are batch operations and require from 30 to 60 minutes to load, press, and discharge. Thus, assuming a 45-minute average batch pressing time, curb presses can process from 370 to 670 pounds tankage per hour, as shown in Table D-9.

Screw presses are designed for continuous operation. They are normally equipped with elevators, hoppers, magnetic separators, and a tempering tank which keeps the tankage warm. Whereas the operation of a curb press requires the full time attention of one man, the screw press can be operated with 25 per cent of a man's time. To use the screw press, the offal must be ground prior to cooking to provide a material that can be fed into the worm shaft. The screw press when operated properly will give press chips with a residual fat content of 7 to 9 per cent. Some operators claim that with proper operation (especially by keeping the press clean) they can press tankage to as low as 5 per cent residual fat. Others have reported that a curb press will only press to 13 per cent fat, while a screw press will only press to 12 per cent fat. For the purpose of making cost estimates, it has been assumed that both the screw press and the curb press can be operated to give 10 per cent residual fat.

Screw presses are available with capacities from 300 to 2000 pounds per hour. Two units with capacities ranging up to 1200 pounds per hour had approximate prices ranging of $14, 000 and $16, 000, including 30 hp motors, magnetic separators, tempering tank, and elevator. Table D-10 shows the estimated cost of two other presses based on a 1000 lb/hr press at a price of $14, 000.

TABLE D-8. CURB CAPACITIES AND COSTS

Nominal Size, tons	Batch Capacity[a], lbs	Approximate Cost, dollars	Electric Pump Required, motor hp	Approximate Electric Pump Cost[b], dollars	Approximate Total Cost, dollars
150	275	3000 – 4000	2	1500	4, 500 – 5, 500
300	400	6000 – 7000	5	2200	8, 200 – 9, 200
600	500	9000 – 10, 000	5	2200	11, 200 – 12, 200

(a) Varies with actual cage size.
(b) Includes motors.

TABLE D-9. CURB PRESS CAPACITIES[a] AND COSTS

Nominal Size, tons	Tankage Pressed, pounds per hr	Approximate Total Cost, dollars	Unit Capacity Cost, $/lb/hr
150	370	5, 000	13. 50
300	530	8, 700	16. 40
600	670	11, 700	17. 50

(a) Assuming 45 minutes average pressing cycle time.

TABLE D-10. SCREW PRESS CAPACITIES AND COSTS[a]

Capacity, lb/hr	Approximate[a] Total Cost, dollars	Unit Capacity Cost, $/lb/hr
500	5, 200	10. 00
1000	14, 000	14. 00
2000	38, 000	19. 00

(a) Based on estimate made from curb presses that cost increases approximately by the 1.43 power of the increase in capacity.

Grinding Equipment

Grinding must be performed at some stage before poultry by-products are compounded into animal feeds. In some cases, small renderers may not grind any of their by-products but sell them as pressed cakes or unground feather meal and unground dried blood. However, the trend is toward renderers doing their own grinding. Hammermills are used to obtain the finish grind, commonly to 8 or 12 mesh. In some instances, separate crushers are used to break the pressed cake and obtain a material that can be fed to the hammermill. However, many hammermills are now manufactured with a built-in cake-crushing mechanism.

Separate crushers with 3 to 5 horsepower per ton per hour of capacity, and hammermills (with and without integral crushers) with 6 to 25 horsepower per ton per hour of capacity, were observed in actual plant installations. The power required to grind a specific quantity of material will depend on the mesh size to which it is ground. A relatively coarse material may be produced with only 10 horsepower per ton per hour of capacity, while a relatively fine material may require 25 horsepower per ton per hour of capacity. For the purpose of making cost estimates, it has been assumed that 25 horsepower per ton per hour is required for both crushing and finish grinding.

Hammermill prices were reported from $700 for 0.5-ton-per-hour capacity to $4,700 for 7-ton-per-hour capacity. A price of $1,500 for a 1.25 ton-per-hour hammermill with an integral crusher was used for estimating prices of other sizes of hammermills in Table D-11.

TABLE D-11. GRINDER DATA AND COSTS(a)

Maximum Capacity, tons/hr	Horsepower	Approximate Price, dollars	Approximate Motor and Starter Price, dollars	Approximate Total Price, dollars
0.5	15	870	360	1,230
1.0	25	1,300	680	1,980
1.25	30	1,500	770	2,27
1.5	40	1,680	870	2,550
2.0	50	2,000	1,120	3,120
2.5	60	2,300	1,570	3,870

(a) Based on the six-tenths power of the capacity difference.

The capacity of a hammermill will vary with the moisture and fat content of the material. Renderers report that the grinding capacity drops off considerably when grease content goes above 15 per cent. Others state that the material should be dried to 5 per cent moisture and pressed to less than 10 per cent fat to obtain meals with good grinding characteristics and good flowing quality. Excessive fat and moisture causes the mill to heat up. Air-cooling the mill with a built-in blower is done in some rendering plants. Mills built with jackets for water cooling could be used, but no example of this was seen in practice. Grinding with a larger than usual internal screen with subsequent screening to proper size outside of the mill and returning the oversize will also reduce the tendency to overheat, by virtue of the recycle stream being naturally cooled.

Auxiliary Equipment

Auxiliary equipment includes: boilers, boiler feed-water treatment equipment, barometric condensers, receiving and holding tanks, holding and storage bins, conveying equipment, magnetic separators, cyclones, bagging scales, and bag-sewing machines.

Boilers

As shown in Figure D-1, boiler cost has been estimated at approximately $5,000 for a 35 BHP boiler and $15,000 for a 250 BHP boiler. These figures are derived from actual boiler purchases made for rendering plants in recent years.

Steam-generation capacities range from 25 boiler horsepower for a plant with one 4 x 7 cooker to 350 BHP for a plant with five 5 x 12 cookers and a steam-tube dryer. Recommended boiler horsepowers for various size cookers were shown in Table D-2. Steam capacity of 25-35 BHP for 4 x 7 cookers and 50-75 BHP for 5 x 12 cookers is recommended by the manufacturers. A 4 x 7 cooker has approximately 100 sq ft of heated surface, and a 5 x 12 cooker has approximately 200 sq ft of heated surface. Thus, cooker steam demands vary from 0.25 to 0.33 BHP per square foot of heated surface. Boiler capacity estimations are based on the higher cooker demand figure of 0.33 BHP per square foot of heated surface. A cooker will operate with the insufficient boiler capacity, but the cooking time is lengthened.

Steam-tube dryers are reported to evaporate from 1.0 to 1.3 pounds of water per hour per square foot when drying poultry by-products. Assuming a 75 per cent thermal efficiency for a steam-tube dryer, the above evaporation rates correspond to steam demands of 0.038 to 0.052 BHP per square foot of heated surface. Under the previous discussion of dryers, it was estimated that a 500 square-foot steam-tube dryer is required for a balanced production rate with a 5 x 12 cooker. A 4 x 7 cooker, which has half the area of a 5 x 12 cooker, would require a 250 square-foot dryer. From the above figures, boiler capacity must be increased by 19 to 26 BHP for a 5 x 12 cooker and by 9 to 13 BHP for a 4 x 7 cooker when a steam-tube dryer is added. For cost-estimating purposes, boiler requirements of 10 and 20 BHP were assumed for adding dryers to 4 x 7 and 5 x 12 cookers, respectively. Table D-12 summarizes the boiler costs for 4 x 7 and 5 x 12 cookers, with and without dryers.

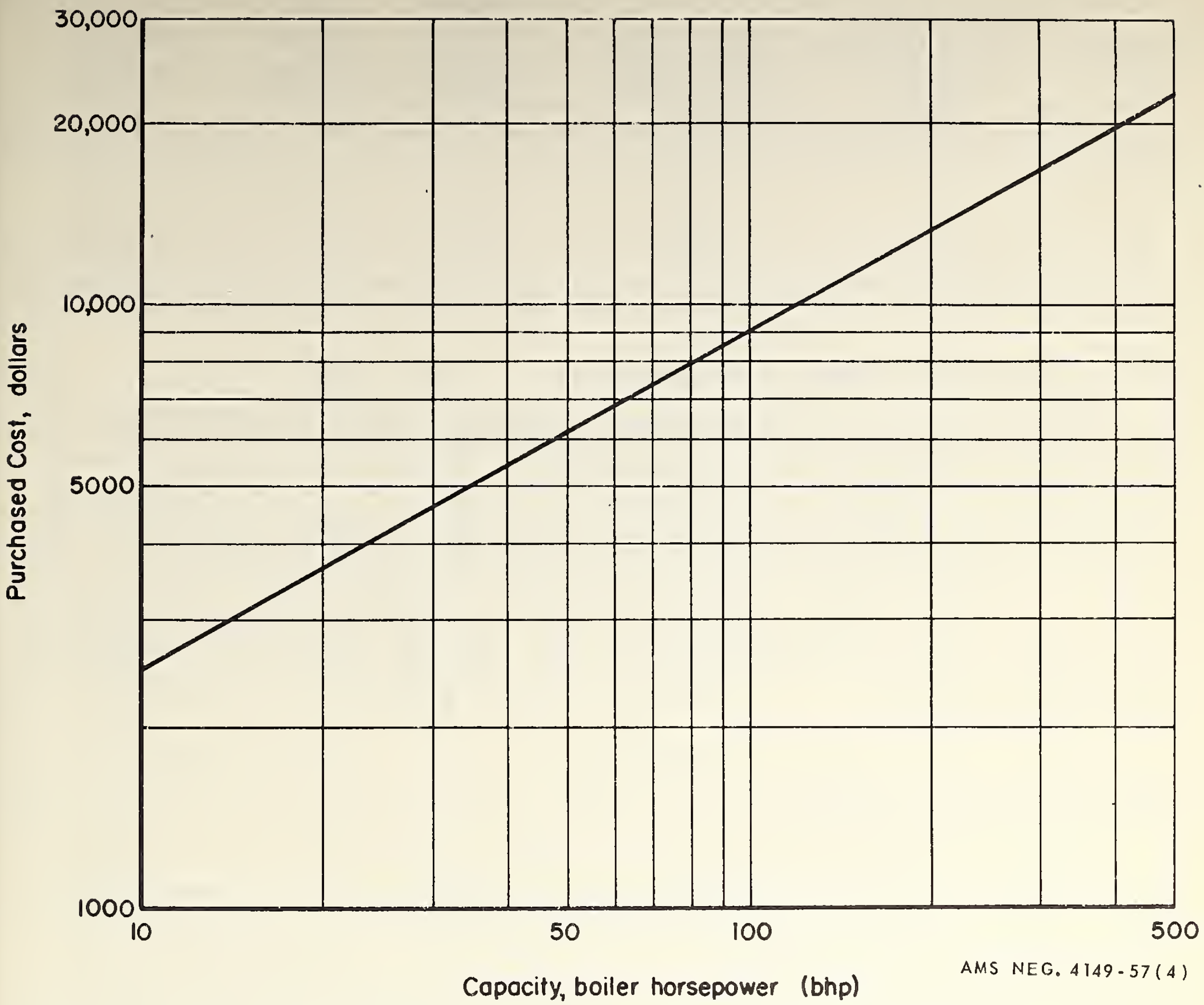

FIGURE D-1. BOILER COSTS

TABLE D-12. BOILER COSTS FOR COOKER AND DRYER COMBINATIONS

Nominal Cooker Size	Estimates per Cooker: Steam Demand for Cooker, BHP	Cost of Boiler for Cooker Only, dollars	Additional Steam Demand for Dryer, BHP	Total Steam Demand, BHP	Cost of Boiler for Cooker and Dryer, dollars
4 x 7	35	5,000	10	45	5,800
5 x 12	70	7,400	20	90	8,400

Boiler Feed-Water Treatment Equipment

Once the boiler is put into operation, most of the steam used will be condensed and returned to the boiler. Equipment for treating feed water is required for initial filling of the boiler and for a 5 per cent make-up allowance for leakage and purging. Water hardness will vary from 5 grains per gallon (gpg) to 30 gpg — or 85.5 ppm to 513 ppm. The lower figure represents water obtained from municipalities that treat the water. The higher figure represents relatively hard well water. It was estimated that the smallest size of industrial water-softening unit (either a twin tank manually regenerated or a single tank automatically regenerated with 30,000-grain capacity per regeneration) will take care of boilers with up to 300 BHP capacity. This softener was estimated to cost $300.

Cooker Waste Gas Condensers

Barometric condensers are commonly used to condense vapor from cookers and to eliminate as many objectionable odors as possible. They are frequently used with hot wells, which are tanks installed so that the end of the tail pipe of the barometric condenser is submerged under the condensed water. The condensed water flows continuously from the hot well to the sewer. A thermostat can be placed in the hot well and connected with a water flow control valve to keep the effluent temperature constant. This control saves on cooling water used by the condenser and insures that the effluent temperature does not get too high and thus let off an excess of objectionable odor. After-burners are commonly provided with the hot well to burn most of the objectionable odors not absorbed by the condensed water.

Hot wells are priced at about $800 to $1,000. Barometric condensers were priced by rendering-equipment manufacturers from $150 to $200. A cost of $1,000 for barometric condenser plus hot well has been assumed. For 4 x 7 cookers, a cooling water flow rate of 75 gpm would be used, while for a 5 x 12 cooker 100 gpm would be required.

Other Auxiliary Equipment

Magnetic separators can vary from a simple $100 manually-unloaded unit to a $800 unit which discharges continuously, and picks out and discharges tramp metal. These units are almost always used with screw presses and have been included in the screw-press price. Use of a magnetic separator ahead of the grinder is also advisable.

Bagging scales cost about $500. Bag stitchers cost around $700.

Tanks and storage lines are another item falling under auxiliaries. Table D-13 shows generalized unit cost figures for such equipment, derived from data on existing and proposed plants.

Fat transfer pumps are usually rotary pumps with capacities of 20 to 50 gallons per minute driven by 1 to 2 horsepower motors. Such pumps cost from $250 to $350 including the motor.

TABLE D-13. TANK AND STORAGE COST

Description	Use	Approximate Size, gallons	Dollars Per Gallon	Dollars Per Pound
Small grease tanks	Receiving and holding	100 – 500	0.50	
Large grease tanks	Storage	10,000	0.15	
Metal storage bins	Receiving and holding	10,000	0.40	0.05 – 0.10
Floor storage bins	Storage	10,000	0.10 – 0.15	0.01 – 0.04

Plant Fixed Capital Estimates

Fixed capital estimates were prepared (see Tables D-14, D-15, D-16, D-17, D-18, and D-19) for six rendering plants representing a range of capacities and capable of producing different combinations of the several poultry waste by-products. Equipment costs for these estimates were derived above.

Installation cost, including piping and wiring, was assumed to be 40 per cent of equipment cost, on the basis of reported experience. Land cost was estimated at $1,000 per acre. Water-well costs were estimated to range from $2,000 to $5,000. Building costs were estimated at $6 per square foot, from reported costs for steel-frame buildings used for rendering plants. Building sizes were estimated from 800 to 3500 square feet. The fixed capital estimate was obtained by adding 25 per cent to the above costs to cover the contractor's fee and contingencies.

TABLE D-14. ESTIMATED FIXED CAPITAL FOR A SINGLE-SMALL-COOKER PLANT

Items	Dollars
1 - 4 x 7 cookers, with 25-hp motors	6, 670
1 - Hammermill, 0. 5 ton per hour, with 15-hp motor[a]	1, 230
1 - Boiler, 35 BHP	5, 000
1 - Water softener	300
1 - Barometric condenser and hot well	1, 000
1 - Bag scale[a]	500
1 - Magnetic separator[a]	100
1 - Cyclone[a]	100
1 - Truck scale	1, 000
Total equipment cost	15, 900
Installation, 40 per cent	6, 400
Water well	2, 000
Land, 0. 5 acre	500
Building, 800 square feet	4, 800
	7, 300
Physical plant cost	29, 600
Contractor's fee and contingency, 25 per cent	7, 400
Fixed capital	37, 000

(a) For a plant processing only offal to produce tankage, these items are not needed; the fixed capital is reduced to $33, 573.

TABLE D-15. ESTIMATED FIXED CAPITAL FOR A TWO-SMALL-COOKER PLANT

Items	Dollars
2 – 4 x 7 cookers, with 25-hp motor each	13, 340
1 – Hammermill, 0. 5 ton per hour, with 15-hp motor[a]	1, 230
1 – Boiler, 30 BHP	7, 400
1 – Water softener	300
2 – Condensers with hot well	2, 000
1 – Bag scale[a]	500
1 – Magnetic separator[a]	100
1 – Cyclone[a]	200
1 – Truck scale	1, 000
Total equipment cost	26, 070
Installation, 40 per cent	10, 500
Water well	3, 000
Land, 0. 5 acre	500
Building, 1800 square feet	10, 800
	14, 300
Physical plant cost	50, 870
Contractor's fee and contingency	12, 700
Fixed capital	63, 570

(a) For a plant processing only offal to produce tankage, these items are not needed; the fixed capital is reduced to $59, 945.

TABLE D-16. ESTIMATED FIXED CAPITAL FOR A TWO-SMALL-COOKER PLANT WITH A PRESS

Items	Dollars
2 - 4 x 7 cookers, with 25-hp motor each	13, 340
1 - Screw press, 500 lb per hour	5, 200
1 - Hammermill, 0. 5 ton per hour, with 15-hp motor	1, 230
1 - Boiler, 70 BHP	7, 400
1 - Water softener	300
2 - Condensers with hot well	2, 000
1 - Bag scale and bag stitcher	1, 200
Fat storage tanks	1, 150
1 - Fat pump	250
1 - Magnetic separator	100
1 - Cyclone	200
1 - Truck scale	1, 000
Total equipment cost	33, 370
Installation, 40 per cent	13, 400
Water well	3, 000
Land, 0. 5 acre	500
Building, 1800 square feet	10, 800
	14, 300
Physical plant cost	61, 070
Contractor's fee and contingency	15, 300
Fixed capital	76, 370

TABLE D-17. ESTIMATED FIXED CAPITAL FOR A TWO-SMALL-COOKER PLANT WITH DRYER

Items	Dollars
2 – 4 x 7 cookers, with 25-hp motors	13, 340
1 – Dryer, steam tube	5, 000
1 – Hammermill, 0. 5 ton per hour, with 15-hp motor[a]	1, 230
1 – Boiler, 90 BHP	8, 400
1 – Water softener	300
2 – Condensers with hot well	2, 000
1 – Bag scale and bag stitcher[a]	1, 200
1 – Magnetic separator[a]	100
1 – Cyclone[a]	200
1 – Truck scale	1, 000
Total equipment cost	32, 770
Installation, 40 per cent	13, 100
Water well	3, 000
Land, 0. 75 acre	750
Building, 2100 square feet	12, 600
	16, 350
Physical plant cost	62, 220
Contractor's fee and contingency	15, 600
Fixed capital	77, 820

(a) For a plant processing only offal to produce tankage, these items are not needed; the fixed capital is reduced to $73, 008.

TABLE D-18. ESTIMATED FIXED CAPITAL FOR A TWO-LARGE-COOKER PLANT

Items	Dollars
2 - 5 x 12 cookers, with 50-hp motors	18, 200
1 - Hammermill, 0. 5 ton per hour, with 15-hp motor[(a)]	1, 230
1 - Boiler, 140 BHP	11, 000
1 - Water softener	300
2 - Condensers with hot well	2, 000
1 - Bag scale and stitcher[(a)]	1, 200
1 - Magnetic separator[(a)]	100
1 - Cyclone[(a)]	200
1 - Truck scale	1, 000
Total equipment cost	35, 230
Installation, 40 per cent	14, 100
Water well	4, 000
Land, 1 acre	1, 000
Building, 2800 square feet	16, 800
	21, 800
Physical plant cost	71, 130
Contractor's fee and contingency	17, 800
Fixed capital	88, 930

(a) For a plant processing only offal to produce tankage, these items are not needed; the fixed capital is reduced to $84, 125.

TABLE D-19. ESTIMATED FIXED CAPITAL FOR A FOUR-LARGE-COOKER PLANT

Items	Dollars
4 – 5 x 12 cookers, with 50-hp motors	36, 400
1 – Hammermill, 1 ton per hour, with 25-hp motor[a]	1, 980
1 – Boiler, 280 BHP	16, 000
1 – Water softener	300
4 – Condensers with hot well	4, 000
1 – Bag scale and stitcher[a]	1, 200
1 – Magnetic separator[a]	100
1 – Cyclone[a]	200
1 – Truck scale	1, 000
Total equipment cost	61, 180
Installation, 40 per cent	24, 420
Water well	5, 000
Land, 1 acre	1, 000
Building, 3500 square feet	21, 000
	27, 000
Physical plant cost	112, 600
Contractor's fee and contingency	28, 100
Fixed capital	140, 700

(a) For a plant processing only offal to produce tankage, these items are not needed; the fixed capital is reduced to $134, 725.

APPENDIX E

OPERATING REQUIREMENTS

Labor Requirements

Labor requirements were found to range from 5 to 12 man-hours per ton of by-product produced. One of the major factors in the higher labor requirements is the extra labor required where material must be pressed. Plant size has a significant effect on the labor requirements, especially where production is below one ton per day.

There are three means by which the high labor requirements of pressing have been reduced by various operators. The simplest method is to bypass the pressing operation by selling the tankage as it comes from the cooker to another renderer whose volume justifies extracting the fat. The second method is to use a continuous screw press which requires less labor to operate than the commonly used curb press. Screw presses have become common in plants preparing seed meal and in large plants rendering material other than poultry wastes. They have been and are being installed in plants rendering poultry wastes. The third method is to mix feathers or feathers and blood with the offal before cooking. The low fat content of the feathers offsets the high fat content of broiler offal so that a product with about 10 per cent fat is obtained.

Reducing the man-hours per ton of product in plants producing less than one ton per day can be done only by using part-time labor. Some reduction is possible if the rendering plant can be operated in such a way that one man's time can be shared with the slaughtering plant. However, until a small, continuous rendering operation requiring very little attention is developed, small plants will be expensive in terms of labor.

Table E-1 shows some estimated labor requirements for several different types and sizes of plants. Labor rates were reported from $1.25 to $1.75 per hour. However, with overtime, the average labor rate in plants visited was around $2.00 per hour; this figure was used in the cost estimates in this report.

Fuel and Utility Requirements

Fuel

Fuel for producing steam, power for the various electric motors, and water requirements can be approximately related to the quantity of water evaporated during the processing. Each pound of water to be evaporated requires approximately 1,100 Btu of energy. Another 100 Btu (approximately 10 per cent) are required for warming up the material. Thus, for every pound of water evaporated, at least 1,200 Btu of thermal energy must be supplied.

TABLE E-1. ESTIMATED LABOR REQUIREMENTS FOR DIFFERENT TYPES AND SIZES OF PLANTS

Plant	Major Equipment	Capacity[a], tons/week	Labor[b] Number of Men/Shift	Man-Hours, per ton of product
A	1 - 4 x 7 cooker 1 - Grinder	4.1	1	14.6
B	2 - 4 x 7 cookers 1 - Grinder	8.25	1	7.3
C	2 - 4 x 7 cookers 1 - Grinder 1 - Dryer	16.5	1-1/2	5.5
D	2 - 4 x 7 cookers 1 - Grinder 1 - Press	8.25	1-1/2	10.9
E	2 - 5 x 12 cookers 1 - Grinder	20.6	1-1/2	4.4
F	4 - 5 x 12 cookers 1 - Grinder	41.2	2	2.9

(a) Based on processing mixed wastes or all wastes separately and operating 12 hours per day.

(b) Assumes that labor schedule can be worked out where half man is required. Also assumes that slaughtering plant personnel bring wastes to the rendering plant.

The thermal efficiency of cookers and steam-tube dryers is assumed to be 85 per cent and the thermal efficiency of a boiler to be 80 per cent. The combined thermal efficiency is 68 per cent. Thus, for every pound of water evaporated, 1,765 Btu of energy must be purchased in fuel. As fuel oil, this represents approximately 0.0128 gallon; as natural gas, this represents 1,765 cubic feet (or 0.001765 thousand standard cubic feet, MSCF). A fuel oil price of $0.14 per gallon (equivalent to a natural gas rate of $1.00 per MSCF) was assumed for the cost estimates. Natural gas rates could vary from $0.25 to $1.10 per MSCF, depending on location and consumption. In most poultry slaughtering areas, the quantity of natural gas required by a rendering plant would be available at an average rate of $0.50 to $0.80 per MSCF. However, many existing slaughtering and rendering plants, even in areas of cheap natural gas, are not located near natural gas service lines; and the gas demand of one rendering plant alone would not justify extension of service lines. For this reason, the cost estimates are based on the assumed fuel oil price. With the assumed fuel oil price of $0.14 per gallon, the fuel cost will be $0.001765 per pound or $3.53 per ton of water evaporated.

Power

Power consumption has been estimated from actual rendering plant costs to be approximately 10 kwhr per million Btu of fuel consumed, which corresponds to 10 kwhr per MSCF of natural gas. Power rates may vary from 0.75 cent to 7.0 cents per kwhr depending both on the location and rate of power consumption. For subsequent calculation, a rate of 3.0 cents per kwhr is assumed. For every pound of water evaporated, 0.01765 kwhr of power will be required, at a cost of $0.00053 per pound or $1.06 per ton of water evaporated.

Water

The major use of water is for the condensation and cooling of cooker vapors. Well water is a common source for cooling water. It is estimated that approximately 75 gallons per minute (gpm) are required for a 4 x 7 cooker and 150 gpm are required for a 5 x 12 cooker. Cooling water consumption can be related to water evaporation; approximately 10 gallons of cooling water is required per pound of water evaporated. Water costs range from $0.01 for river and cooling tower water to $0.25 and more for some city water. For the costs estimates, it is assumed that well water can be furnished at a cost of approximately $0.02 per thousand gallons. Thus, the cooling water cost is estimated to be $0.0002 per pound or $0.40 per ton of water evaporated.

APPENDIX F

PROCEDURES

The work conducted in this study consisted of obtaining general information and engineering data on the rendering of poultry wastes, correlating the information and data received, and calculating material balances, fixed capital estimates, operating cost estimates, and estimated profits for several sample rendering plants and preparing schematic layouts for these plants. Information was obtained from the following sources: the literature, poultry slaughterers, renderers, and rendering equipment manufacturers. The bulk of the correlation of this information and the detailed cost estimates are contained in the Appendixes.

Literature Survey

The primary literature sources were: Bibliography on Poultry and Egg Marketing published by the New England Research Council on Marketing and Food Supply, various University Agricultural Experiment Station bulletins, Poultry Processing and Marketing (formerly U. S. Egg and Poultry Magazine), Poultry Science, and American Meat Institute publications. A complete list of literature references is contained in Appendix G.

Questionnaires

Questionnaires were prepared and mailed to both poultry slaughterers and renderers to obtain waste-yield data and general information on the disposal and rendering of poultry wastes. The information obtained from these questionnaires was used as a basis for selecting plants to be visited.

Plant Visits

Trips were made to the following three geographical areas to obtain detailed information on poultry waste yields, rendering by-product yields, and general operating and design data: Southern Pennsylvania and the Shenandoah Valley of Virginia, Western Ohio, and Southwestern Missouri and Arkansas. Information was obtained during these visits by discussion with plant operators, review of plant records and data, and observation of plant operations.

Contacts With Equipment Manufacturers

Equipment cost data and some engineering information on rendering operations were obtained from rendering equipment manufacturers. This information was gathered by letters, telephone calls, and personal visits.

APPENDIX G

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