OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

D00471

United Nations Industrial Development Organization

[illegible]
[illegible]
[illegible], Illinois, USA, [illegible] November [illegible]

ISOLATED SOY PROTEINS AND SOY PROTEIN CONCENTRATES [1]

by

Dale W. Johnson
[illegible] Products, Inc.
Park Ridge, Illinois
United States of America

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

[illegible]

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche.

United Nations Industrial Development Organization

[illegible]

Peoria, Illinois, USA [illegible] - [illegible] November [illegible]

SUMMARY

ISOLATED SOY PROTEINS AND SOY PROTEIN CONCENTRATES [1]

by

[illegible] Johnson
Crest Products Inc
Park Ridge, Illinois, USA

There has been an increasing interest in the use of isolated soy proteins and soy protein concentrates in foods largely because of flavour problems associated with soy flour and grit products. Also, the presence of fibre and other constituents in soy flour and grit products limit their use or eliminate the possibility of their application in certain types of food products.

In the case of feeding [illegible] populations in developing nations, if it were possible to supply isolated soy proteins or soy protein concentrates, the acceptability of soy products would be enhanced. In the United States and certain other affluent nations, the increasing costs of conventional protein-containing foods has resulted in an increasing interest in the use of isolated soy proteins or soy protein concentrates as partial or complete replacements for conventional protein foods because of the potentially lower costs.

1/ [illegible] and [illegible]

[illegible]

Information on commercially used processes for producing isolated soy proteins and soy protein concentrates is closely held by the companies producing such products. However, there have been a number of patents issued giving different procedures which have been used for producing such products.

In this paper patents were selected, on the basis of work carried out by individuals with a great deal of experience in the field of soy protein products, to be used for purposes of illustrating typical procedures which might be used to produce isolated soy proteins and soy protein concentrates and to be used as a basis for calculating yields and costs.

A discussion is presented briefly on factors influencing yield and descriptions of the processes used for producing such products.

Calculations are made on the basis of certain assumptions, to show the influence of heat processing of soy flakes on yields and estimated costs for producing isolated soy proteins on the basis of different production levels.

As one would expect, in the case of isolated soy proteins, at a relatively low monthly production rate, the over-all costs are considerably higher, on a per pound of protein basis, than at the higher monthly production rates.

While the cost calculations are based on the assumption of an ideal system where the material balance recovery at various points in such a process would be good, it is known that in actual practice this would not be the case. Comments are made on these calculations from the standpoint of practical considerations.

Flow sheets are presented on three processes which are used commercially for producing soy protein concentrates. The material balance recovery and details of one process, namely the acid leach process, are discussed rather completely.

It is pointed out that one of the most important facets of production of isolated soy proteins or soy protein concentrates is the waste disposal problem.

* * * * *

It [illegible] to develop [illegible] of protein [illegible] areas of the [illegible] ing to prices [illegible] products [illegible] requirements in the usually accepted [illegible]

It [illegible] sufficient [illegible] taste, texture [illegible] formulations. It is essential [illegible] diet [illegible] room for [illegible] available regardless of whether these [illegible] protein containing [illegible] acceptability.

In cereal [illegible] generally [illegible] very low and, in many cases, the [illegible] the essential amino acids, so that even if the protein could be concentrated, its relative nutritional value, by itself, would be rather low or its ability to fortify other proteins from an amino acid [illegible] would be limited. [illegible] possible interesting cereal grain product [illegible] varieties have been found with a reported protein content [illegible] available information [illegible]. If such a crop could be cultivated in various areas of the world and the yields are satisfactory, this could be a very interesting [illegible].

Rice is certainly a good protein from the standpoint of quality, but the protein content of the varieties [illegible] presently being produced is very low.

When one considers oilseeds from the standpoint of available knowledge of nutritional data, production of special edible protein products, etc., far more has been done with soybeans than any of the other oilseeds or vegetable protein-containing crops. From the standpoint of amino acid composition and the ability to be used as a supplement for cereal products such as corn and wheat, soybeans have an advantage over products such as sesame, peanut, cottonseed, safflower and sunflower. While there are many parts of the world where soybeans are not grown, it appears that there are still many areas where it may be possible to grow the proper variety of soybeans to make them available for processing into ingredients which may be used in foods. While other oilseeds may be more desirable as sources of oil from an economic and acceptability standpoint, most of the countries needing protein still need more oil products than are presently available.

This paper [illegible] ingredients [illegible] be made [illegible] functional characteristics [illegible] such products [illegible] markets [illegible] food processing [illegible] desirable [illegible] protein [illegible] more difficult [illegible]

While the general [illegible] protein [illegible] protein concentrates [illegible] commercial [illegible] are closely held [illegible] been [illegible] factors [illegible]

[illegible] potential [illegible]

[illegible] basis of [illegible] in the process [illegible] case, and [illegible] the dimension [illegible] purposes, it is necessary [illegible] producing the [illegible] characteristics [illegible] We know the order [illegible] practical [illegible] composition [illegible] variation from [illegible] conditional [illegible] as well as [illegible] scale of [illegible] products are [illegible].

Time will not permit [illegible] of all [illegible] reasons for making certain assumptions. [illegible] could have been used, but those which were [illegible] calculations and for possible [illegible] take. [illegible] did not [illegible] was necessary [illegible] error, but [illegible].

[illegible]

Following [illegible] the yields one would [illegible] product [illegible] extraction, [illegible] flake [illegible] digestible [illegible].

[illegible]

The Process

In [illegible] a [illegible] is presented for a process for producing [illegible] Company), [illegible] and [illegible] concentration of [illegible] yields [illegible] flakes and [illegible] yields of 35 to [illegible] basis. The figures for the initial [illegible] adjusted to [illegible] insoluble [illegible] around [illegible].

The acidified liquor [illegible] was then allowed to stand [illegible] the [illegible] to settle and about [illegible] water was added to the decanted curd [illegible] followed by [illegible] decantation [illegible] filtered to remove as much excess [illegible] [illegible] tubs [illegible]

[illegible], and are dried [illegible] the protein [illegible] to be [illegible]

[illegible] nutritional value in [illegible] types of mixed products, [illegible] to increase [illegible] in a [illegible] with [illegible] that [illegible] dispersible or [illegible] would be necessary for it to be [illegible]

Equipment Flow Diagram

An equipment flow diagram for the process shown in Figure One is presented in Figure Two. [illegible] type of equipment required, as shown in Figure Two, would be the [illegible] for producing isolated soy proteins. A [illegible] product would be produced [illegible] a process which would be reasonably [illegible] from the standpoint of final yield of product, waste disposal

problems, [illegible] [illegible]

[illegible] equipment [illegible] [illegible] might be [illegible] in this way [illegible] type of [illegible] than one [illegible] filter, [illegible] will be shown [illegible]

[illegible] filter wheels, [illegible] by [illegible]

[illegible] would probably be [illegible]

[illegible] to [illegible] either by [illegible] by a [illegible] whereby the protein is virtually un-hydrolized, does create a problem in that [illegible] 17 to 23% [illegible]

[illegible] different [illegible] than [illegible]

[illegible] for cut or drying [illegible]

[illegible] in the event [illegible] and dry, large chunks [illegible]

[illegible] calculation are [illegible]

[illegible] was little caused, [illegible]

[illegible] total [illegible]

[illegible] the globular type [illegible] solutable.

[illegible] solids portion

were [illegible] that there would be [illegible] to loss of protein [illegible] from the [illegible] figure. If the [illegible] amount of [illegible]

[illegible] were to [illegible] the [illegible] portion using a [illegible] of [illegible] the [illegible]

[illegible] centrifuge [illegible] centrifuge [illegible]

[illegible] depending on the [illegible] used.

By using [illegible] the [illegible] could be [illegible]

[illegible] capital [illegible] of product would be [illegible] and the problems of [illegible] would not be as great.

[illegible] and elimination of [illegible] could create [illegible] from the [illegible].

In Table [illegible] that of [illegible] made on the basis of [illegible] of various products [illegible] is given in Table Two. [illegible] summary of the final products [illegible].

Again [illegible] these tables are based on the assumption [illegible] 100% [illegible] of products from the starting raw materials. In the case of the calculations [illegible] having 70% of the protein [illegible] Table Two, based [illegible] and 39.6 [illegible] of soluble [illegible] from [illegible] Figure One was [illegible] between [illegible] the fact that the [illegible] the 70% [illegible] able [illegible] calculation purposes)

or in process all of the solid [illegible] were not actually separated but [illegible] also, there [illegible] the [illegible] it is [illegible] slightly [illegible].

[illegible] where [illegible]

[illegible] go to the [illegible] the [illegible] 1:3,000 [illegible] reaction the [illegible] than the calculated values for [illegible].

[illegible] the water dispersible [illegible] protein which can be recovered and the [illegible] would be recovered. Also

[illegible] would expect, the
[illegible], whom
[illegible]
[illegible] and the fact
[illegible] acid
[illegible] in the
[illegible]

[illegible] defined
[illegible] factors used for
[illegible]
[illegible] extraction plant,
[illegible] so that the finished
[illegible] extraction,
[illegible] yield of
[illegible] for live-
[illegible] economically feasible
[illegible] yields would
[illegible] therefore [illegible] is required for
[illegible] products.

[illegible] were near
[illegible] reflected,
[illegible] the same,
[illegible] precipitable.
[illegible] precipitable protein

[illegible]

[illegible] from the [illegible]
[illegible] time,
[illegible] purposes.
[illegible]

[illegible]

[illegible] and
[illegible] and
[illegible]
[illegible]
[illegible]
[illegible] States.

more still is a large market for 44% protein soybean meal. In some cases, it may be [illegible] and recover the value of the [illegible] In other cases, [illegible] In order to [illegible] which would be [illegible] producing [illegible] for the value [illegible] on the basis of the par- [illegible] meal and the [illegible]

[illegible] assumed that [illegible] the assumption [illegible] [illegible] and 33% [illegible] [illegible] soy protein [illegible] credit [illegible] soybean meal or [illegible] quite surprising [illegible] different yield [illegible] isolated soy protein.

In [illegible] priced [illegible] there is no futures market and [illegible] [illegible] higher in [illegible]

[illegible] first used [illegible] 30 cents per pound [illegible]

[illegible] concentrate [illegible]

[illegible]

[illegible] isolated protein [illegible] per pound [illegible] the depreciation cost per pound [illegible] on the use of

[illegible]

[illegible]

[illegible] per pound or [illegible] per month [illegible] using the [illegible] per [illegible] slightly [illegible] automatically.

[illegible] States [illegible] on the [illegible] pounds per [illegible] that [illegible] per pound of [illegible] down [illegible]

[illegible]

[illegible] isolated soy protein [illegible] based on [illegible] shown in [illegible] plant [illegible]. [illegible], technical [illegible] profits.

[illegible]

[illegible]

[illegible]

[illegible] for each [illegible] different [illegible] water [illegible] amount of water [illegible]

[illegible]

[illegible] for [illegible] that [illegible]

[illegible]

There are three types of [illegible] being produced in the United States.

[illegible]

[illegible] detailed [illegible] which has been [illegible] of the [illegible]

[illegible] subjected to water extraction, one [illegible]

[illegible]

[illegible] in the [illegible] field and [illegible] as well as [illegible].

[illegible]

The [illegible] which [illegible] which has considerably [illegible] at the isoelectric [illegible] procedure. This [illegible] April 7, 195[illegible], assigned to the [illegible].

[illegible] Figure [illegible] is an equipment flow diagram [illegible] one of the procedures they describe [illegible].

[illegible] gallons [illegible] 55° to 60° F. (12.8° to 15.6°C.) [illegible] soy flour in a stainless steel tank [illegible] and 22 inches (56 [illegible]) deep. [illegible]. After [illegible], and [illegible] settle [illegible] with [illegible] and [illegible]. The [illegible]. The curd [illegible] as follows:

[illegible] to [illegible] 120° F. [illegible] requires about 12 [illegible] range from [illegible] processing [illegible] to facilitate spray drying [illegible] as follows:

The [illegible] is translucent [illegible] of [illegible] lysine [illegible] flows

[illegible]

Moisture	[illegible]
Protein	[illegible]
[illegible]	[illegible]
Ash	[illegible]
Fat	[illegible]
pH	[illegible]

*Calculated on [illegible] basis.
[a]5 parts dispersed in [illegible] of water.

In the [illegible] add the soy flour to water to produce a slurry, then acidify with hydrochloric acid [illegible] near the isoelectric point, around 4.4 to 4.6, allow [illegible] supernatant liquid. They then add an [illegible] to settle [illegible] with the [illegible]

[illegible]

[illegible] liquid

[illegible] contains [illegible] the [illegible] and flavor constituents would [illegible]

[illegible] one would obtain a yield of [illegible] moisture [illegible] with [illegible] yield of about [illegible] but their actual rated protein content is slightly lower, being [illegible]. Since there are

[illegible]

[illegible]

Waste [illegible]

[illegible] waste product of [illegible] of finished produ[illegible]

[illegible] show eight [illegible]

[illegible] therefore the concentration would be [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] there is needed [illegible] concentrates.

[illegible]

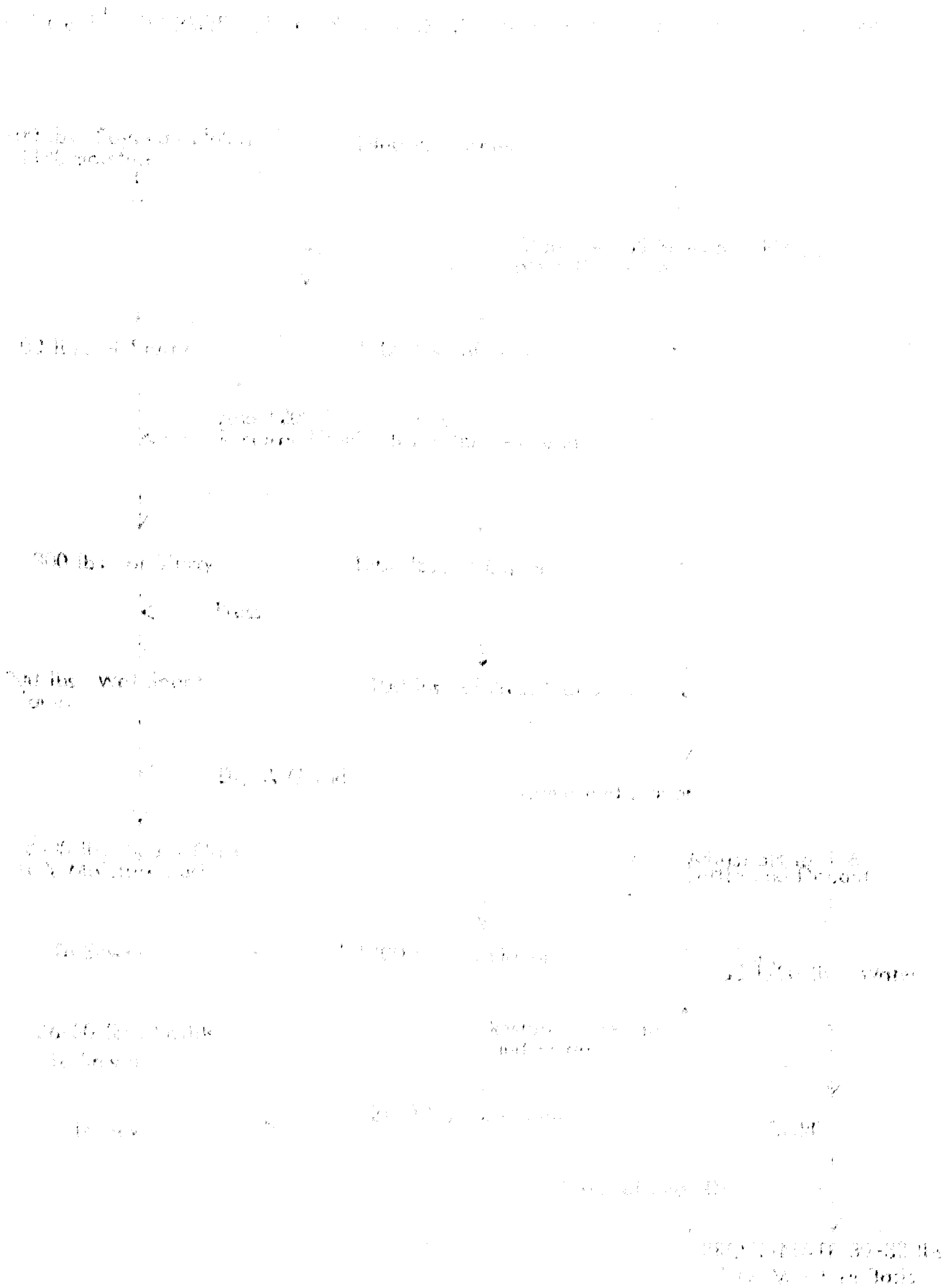
[illegible] it would be highly desirable [illegible] to such [illegible] replace [illegible]

[illegible] found in [illegible] concentrates. [illegible] the [illegible] cases, [illegible] [illegible]

[illegible] operation, in [illegible] study the sources of

[illegible]

[illegible]



[illegible] 2,881,[illegible] [illegible] assigned to Glidden Co.

FIGURE TWO

FLOW DIAGRAM - ISOLATED SOY PROTEIN PRODUCTION

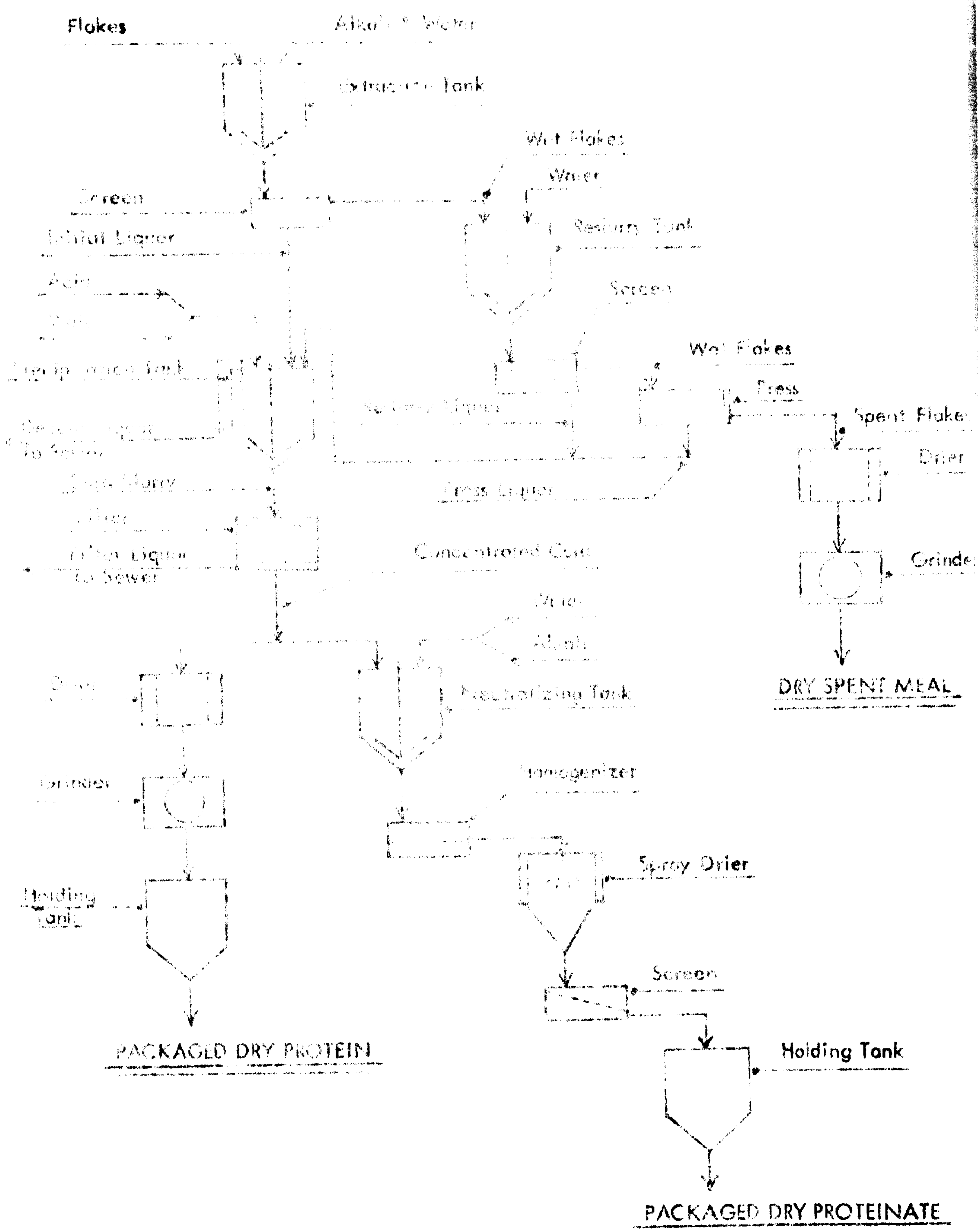


FIGURE 3

FLOW DIAGRAM ... TO PRODUCE SOY PROTEIN CONCENTRATE

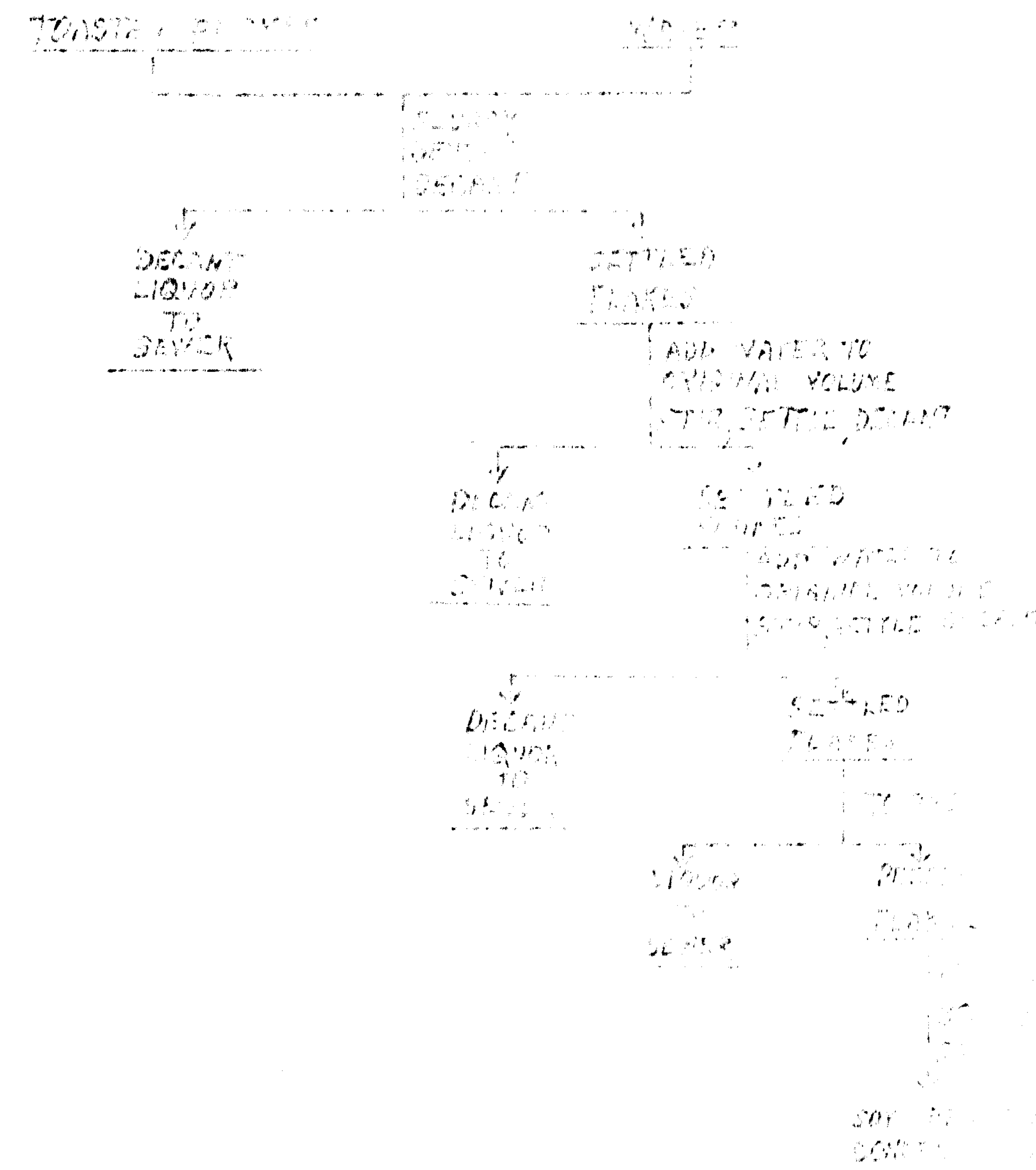


FIGURE 4

FLOW DIAGRAM OF WATER LEACH PROCESS TO PRODUCE SOY PROTEIN CONCENTRATE

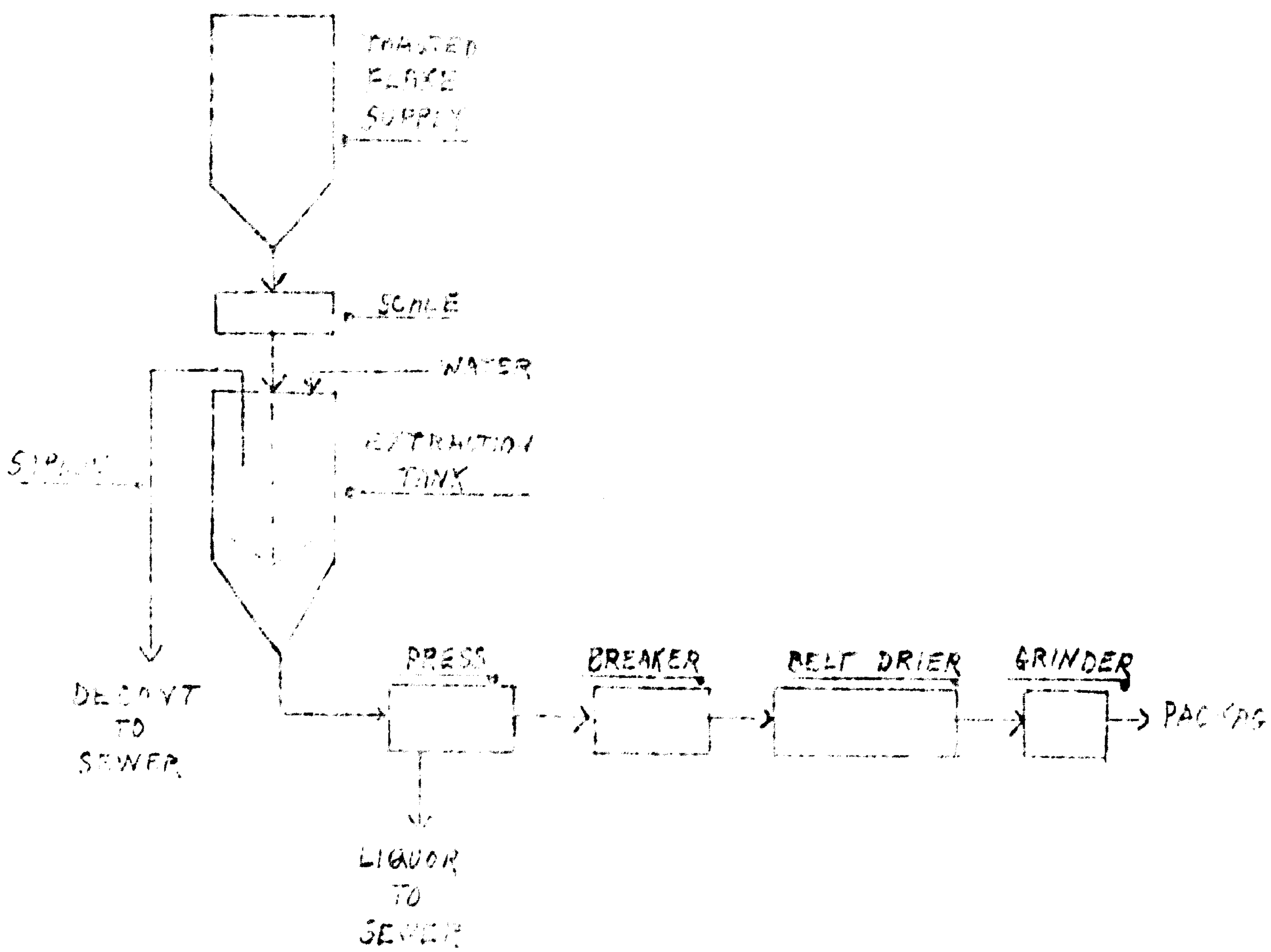


FIGURE 5

FLOW DIAGRAM OF AQUEOUS ALCOHOL LEACH PROCESS TO PRODUCE SOY PROTEIN CONCENTRATE

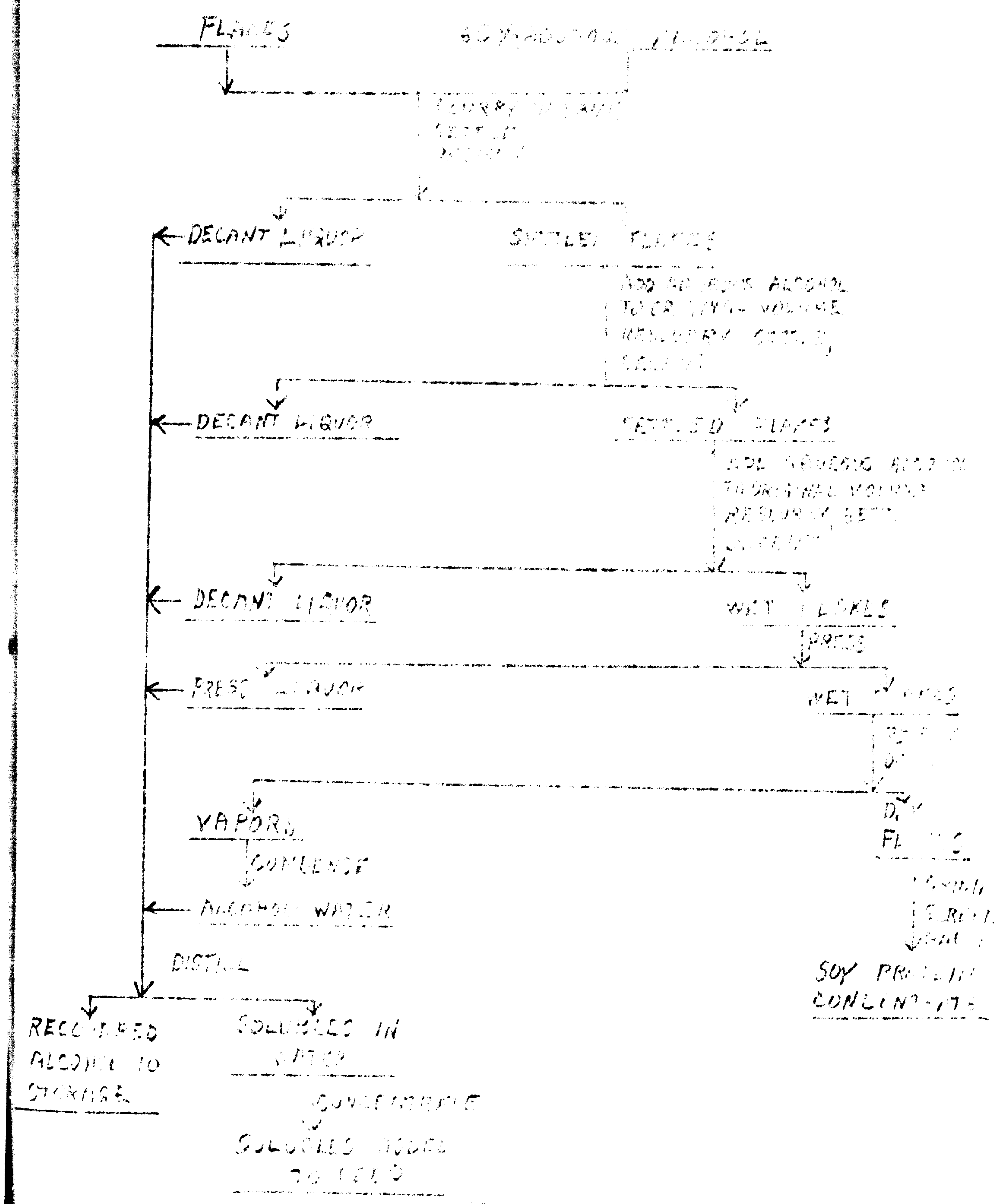


FIGURE 6

FLOW DIAGRAM OF AQUEOUS ALCOHOL LEACH PROCESS TO PRODUCE SOY PROTEIN CONCENTRATE

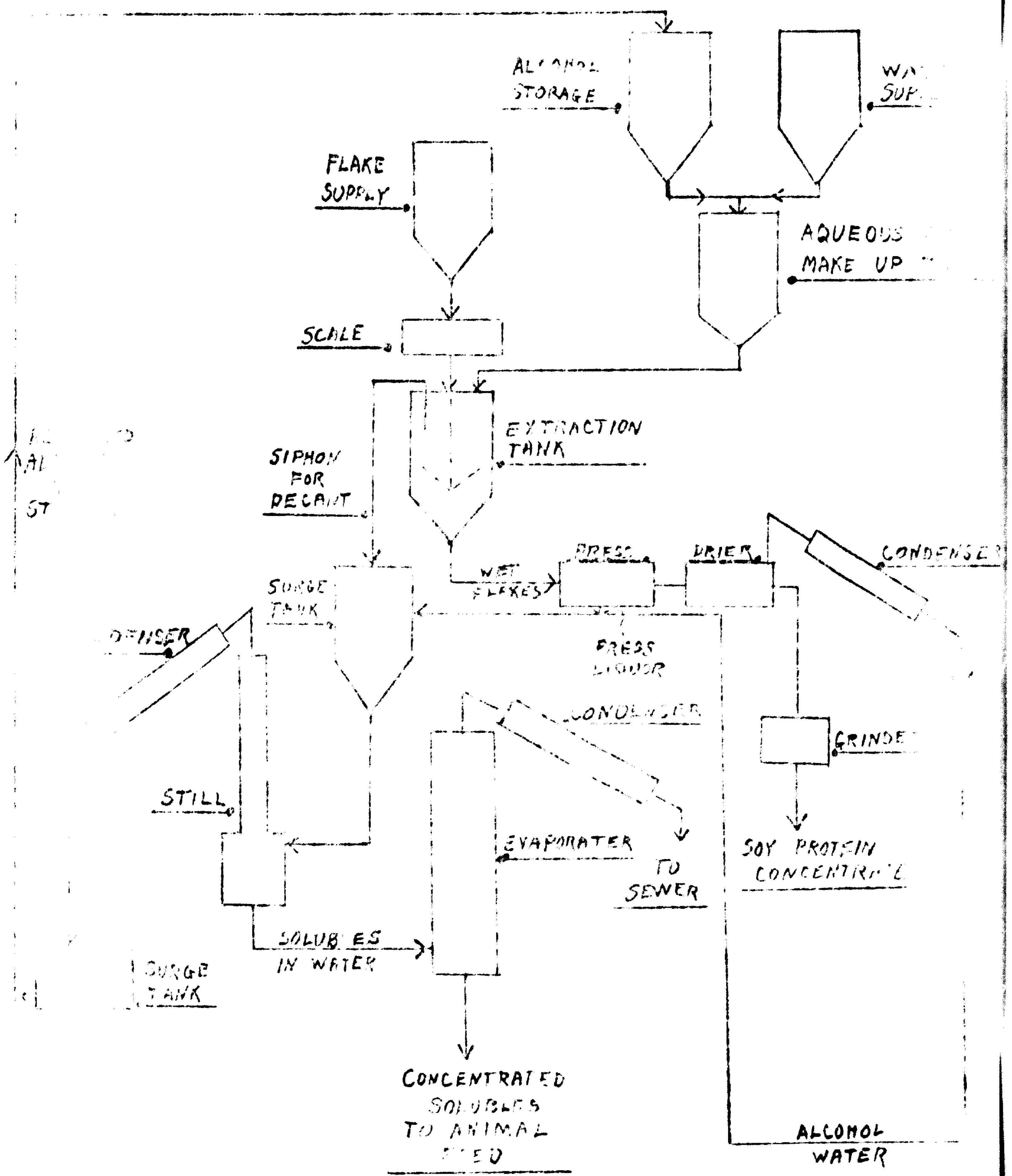


FIGURE 7

FLOW DIAGRAM FOR THE SAIR PROCESS OF PRODUCING SOY PROTEIN CONCENTRATE

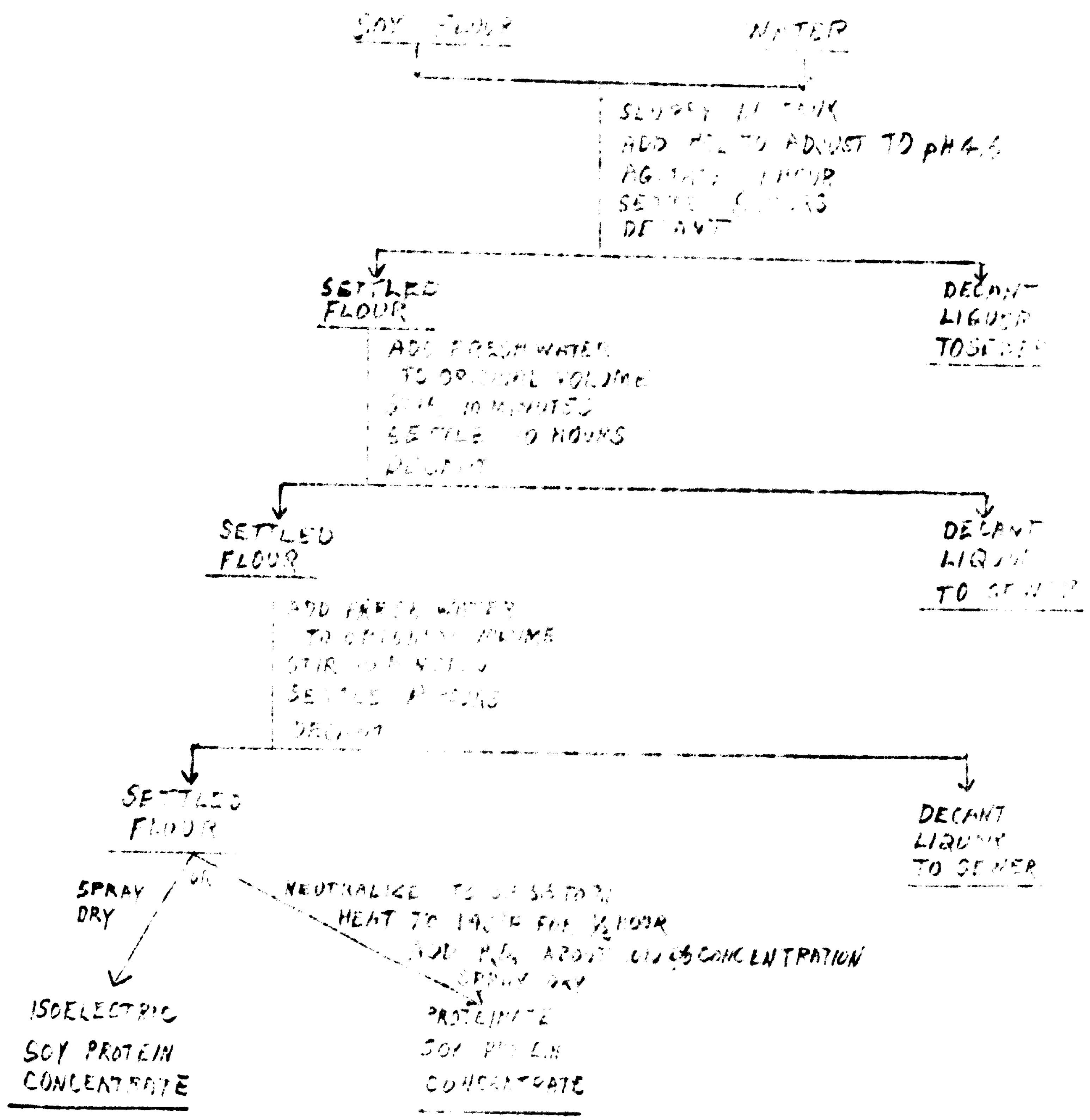


FIGURE A

FLOW DIAGRAM FOR THE SAIR PROCESS OF PRODUCING SOY PROTEIN CONCENTRATE

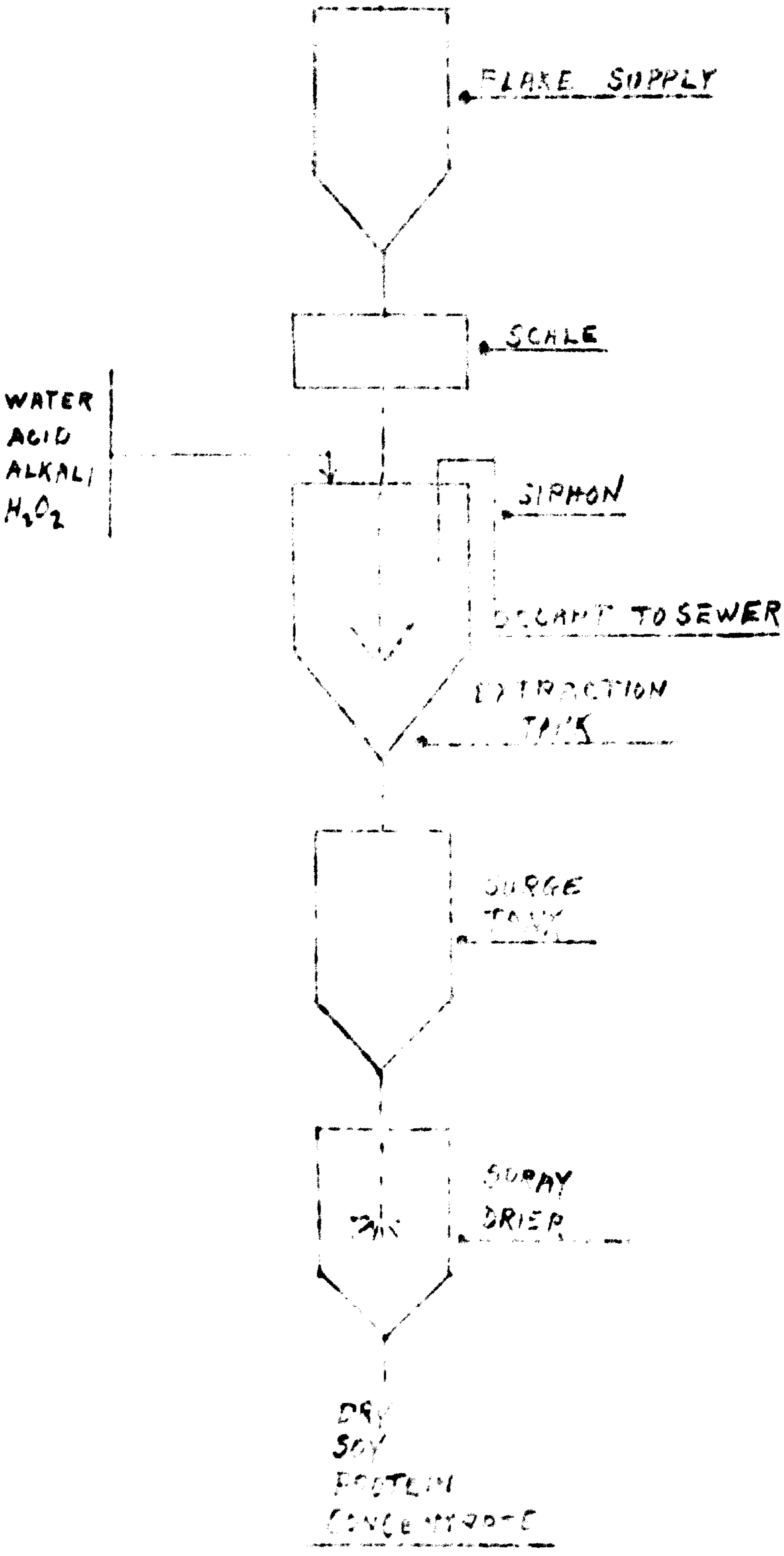


TABLE ONE

Calculated yields and composition of various fractions (in lbs.) from 100 lbs. of flakes in a process used to produce edible isolated soy protein using flakes containing 52.0% protein on a 10% moisture basis. It is assumed that 70% of the total protein is dispersible, that 10% of the total protein (5.2 lbs.) was not acid precipitatable and other solubles amount to 20.2 lbs.

STEP	LIQUOR					SOLIDS OR SLURRY					
	H_2O	Total Dispersed Protein	Nonprecipitable Dispersed Protein	Non-Protein Solids	Insolubles	H_2O	Dispersed Protein	Nonprecipitatable Dispersed Protein	Precipitated Protein	Non-Protein Solubles	Insolubles
1-Initial extraction mixture	1410	36.4	5.2	20.2	33.4	-	-	-	-	-	-
2-Material from Step 1 settled and 1200 lbs. decanted	1154.7	29.1	4.15	16.2	-	255.3	7.3	1.05	-	4.0	33.4
3-Solids from Step 2 reslurried with 1200 lbs. H_2O and 1200 lbs. decanted	1191.0	5.84	.84	3.2	-	264.3	1.46	0.21	-	0.8	33.4
4-Press 100 lbs. from solids in Step 3	99.2	0.49	0.07	0.27	-	165.1	0.97	0.14	-	0.53	33.4[2]
5-Combined liquor from Steps 2, 3, and 4	2444.9	35.43	5.06	19.67	-	-	-	-	-	-	-
6-Precipitate Protein in combined liquor and decant 1700 lbs	1693.2	-	3.44	13.4	-	761.7	1.62	1.62	30.37	6.27	-
7-Solids from Step 6 reslurried in 1700 lbs. of water. Decant and filter	2151.4	-	1.38	5.39	-	349.6	0.24	0.24	30.37	.88[1,3]	

[1] Assumed that precipitated protein would hold 80% water when filtered.

[2] Represents (when dried) 34.70 lbs. of spent flakes with 16.57 lbs. of protein which on a 12% moisture basis is 39.6 lbs. with 41.8% protein.

[3] Represents (when dried) 31.49 lbs. of isolated soy protein with 30.61 lbs. protein which on 10% moisture basis is 35.0 lbs. of product with 87.5% protein.

TABLE TWO

Calculated yields of isolated soy protein and spent flakes, and the amount of solubles and water to the sewer, in pounds, based on [illegible] lbs. of flakes with 52% protein (10% moisture basis), varying amounts of water dispersible protein, assuming complete recovery of all components, that [illegible] of the protein is not acid-precipitated and about 20.2% of the flake weight is non-protein solubles.

Percent water Dispersible Protein in Flakes	Pounds of Isolated Protein Recovered (10% moisture basis)	Percent Protein In Isolate	Spent Flake Recovered (12% moisture basis)	Percent Protein in Spent Flakes	To Sewer: Water	To Sewer: Solids	To Sewer: Protein
90	46.5	87.8	28.2	22.9	3670	23.3	4.8
70	35.0	87.5	39.6	41.8	3830	23.6	4.8
50	23.4	87.1	54.0	49.5	3920	24.1	4.9

TABLE THREE

CALCULATIONS ON SOY FLAKE COST PER POUND OF ISOLATED SOY PROTEIN BASED ON PERCENT YIELD (OF PROTEIN, 10% MOISTURE BASIS) AND APPLYING A CREDIT FOR RECOVERY AND SALE OF SPENT FLAKES (12% MOISTURE BASIS)

Assume flake cost [illegible] per short ton and spent flakes sold on a protein basis compared to 44% protein soybean meal at $[illegible] per short ton, less $5.00 for increased fiber.

	Yield (percent)				
	23.4	30.0	33.0	35.0	46.5
Flake cost per pound protein	16.2	14.2	12.2	12.[illegible]	9.1
Spent flake credit per pound protein	[illegible]	5.7	4.[illegible]	[illegible]	1.1
Net Flake Cost	[illegible]	[illegible]	[illegible]	8.2	8.0

Assume flake cost $[illegible] per short ton and spent flakes sold on a protein basis compared to 44% protein soybean meal at $[illegible] per short ton, less $5.00 for increased fiber.

	Yield (percent)				
	23.4	30.0	33.0	35.0	46.5
Flake cost per pound protein	[illegible]	[illegible]	[illegible]	15.6	11.7
Spent flake credit per pound protein	[illegible]	[illegible]	[illegible]	5.2	1.5
Net Flake Cost	10.7	10.6	10.4	10.4	10.2

TABLE FOUR

ESTIMATED COST TO BUILD AN ISOLATED SOY PROTEIN PLANT AT VARIOUS PRODUCTION LEVELS, BASED ON APPROXIMATELY 30% YIELD, NOT INCLUDING COST OF LAND, ASSUMING [illegible] SUPPLY, POWER PLANT, SHOP AND MAINTENANCE SERVICES ARE AVAILABLE. DEPRECIATION COST PER POUND OF PROTEIN BASED ON 40 YEAR BUILDING DEPRECIATION RATE AND 10 YEAR EQUIPMENT DEPRECIATION RATE ON A STRAIGHT LINE BASIS.

Projected Production In Pounds/Month	100,000	250,000	500,000	750,000	1,000,000
Estimated Plant Cost .	$1,000,000	$1,250,000	$1,800,000	$2,250,000	$2,500,000
Approximate Monthly Depreciation	$6,450	$8,300	$12,700	$16,200	$18,000
Depreciation Cost Per Pound of Protein	6.45¢	3.32¢	2.54¢	2.16¢	1.80¢

TABLE FIVE

COMPARISON OF PLANT MANUFACTURING COST WITH DIFFERENT YIELDS OF ISOLATED PROTEIN BASED ON THE SAME AMOUNT OF FLAKES REQUIRED TO PRODUCE 1,000,000 LBS. OF PROTEIN PER MONTH AT ABOUT A 30 % YIELD.

Percent Yield of Isolated Protein	30	35	44
Pounds Of Protein Produced from same Quantity of Flakes at Percent Yield Given	1,000,000	1,200,000	1,600,000
Estimated Plant Cost	$2,500,000	$2,600,000	$2,700,000
Manufacturing Cost/Pounds of Protein	8.5¢	7.7¢	6.6¢

TABLE SIX

COMPARISON OF PLANT MANUFACTURING COSTS WITH A PRODUCTION RATE OF 100,000 LBS. AND 1,000,000 LBS. OF ISOLATED PROTEIN PER MONTH BASED ON ABOUT 25-30% YIELDS.

Production Rate - Lbs./Month	100,000	1,000,000
Estimated Plant Cost	$1,000,000	$2,[illegible],000
Manufacturing Cost/Lbs. of Protein	18.4¢	8.5¢

TABLE SEVEN

TOTAL PRODUCTION COST PER POUND OF ISOLATED SOY PROTEIN AT VARIOUS PRODUCTION LEVELS ASSUMING ABOUT 25-30% YIELD OF ISOLATED PROTEIN USING FLAKE COSTS AS INDICATED IN TABLE [illegible].

Projected Production in Pounds per Month	[illegible]	250,000	500,000	750,000	1,000,000
Production Cost per Pound*	[illegible]	27.6¢	23.7¢	22.9¢	21.7¢

*Does not include administration, overhead, sales, technical service, research, interest or profit.

TABLE EIGHT

AMOUNT OF WATER USED IN PROCESSING PER POUND OF ISOLATED SOY PROTEIN [illegible] AT DIFFERENT YIELD LEVELS.

Yield Level (percent)	Lbs. of Water Used Per Lbs. of Protein Produced
46.5	92.5
35.0	123
23.4	184

TABLE N[illegible]

Composition of slurries (in pounds) at various steps in the Sair process of producing soy protein concentrates, assuming soy flour with 52.5% protein, 10% moisture, that 10% (5.2 lbs.) of the protein is not precipitated with acid and the non-protein solubles amount to 20.2%, based on the extraction of 100 lbs. flour and In[illegible] flour [illegible] the first extraction at pH of 4.5.

	Step 1 1st Slurry	Step 2 2nd slurry - Decant 50% of water from Step 1 & add equal amount of H_2O	Step 3 3rd slurry - Decant 50% of water from Step 2 & add equal amount of H_2O	Step 4 Decant[1] 50% of water from Step 3	Total Decant
Amount of soluble protein	5.2	2.6	1.3	.65	
Amount of non-protein solubles	20.2	10.1	5.05	2.52	
Amount of insoluble protein	47.3	47.3	47.3	47.3	
Amount of total insolubles	64.6	64.6	64.6	64.6	
Amount of water added	1000	500	500	-	
Total water	1010	1010	1010	510	
Total solids dry basis	90	77.3	71.0	67.8	
Total solids-3.3% moisture basis	93.1	79.9	73.4	70.1	
Water in decant		500	500	500	[illegible]
Total solids in decant		12.7	6.4	3.2	[illegible]
% Protein in decant dry basis		.52	.26	.13	0.30
% solids in decant dry basis		2.54	1.23	.64	1.49

1 - The [illegible] from Step 4 is spray dried as is or neutralized-on 3.3% moisture, 70.1% yield with [illegible] in

25. 5. 72