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PROCESSING OF SOYBEANS
IN INDIA
FEASIBILITY STUDY (TECHNICAL)
VOLUME I.

BY

SERVOTECH

DESIGN, CONSULTING AND
CONSTRUCTION ENGINEERS
POST BOX 6073
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FOR

UNITED STATES AGENCY FOR
INTERNATIONAL DEVELOPMENT
INDIA.

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CONCLUSION AND RECOMMENDATIONS

1. In the context of the heavy shortage of edible fats and extensive protein mal-nutrition in the country, the processing of soybeans is no mere commercial activity, but an industry of national importance.

2. For a new processing complex of this type, it is recommended to locate the Project in the area in which the beans are grown. The freight on the Railways, assuming a haul of 500 KM, for soybeans, oil and meal per tonne are respectively Rs.47.8 (Tariff 67.5B), Rs.46.10 (Tariff 65) and Rs.19 (Tariff 25A). Movement of meal costs only about 40% of that of oil or beans. The quantity of oil obtained is only 20% maximum of the beans processed. Movement of beans is the most expensive proposition.

3. In the first phase of operations, soybeans are to be processed for the recovery of oil and production of edible flour and only after meeting all the requirements of edible flour in the country should manufacture of commercial soymeal be permitted.

   The 'Bal-Ahar' programme is said to require 12,500 M.T of edible flour at 25% level fortification. The large-scale feeding programme of pre-school children initiated by the Ministry of Social Welfare is expected to consume an equal quantity of edible flour. The roller flour mills in Calcutta, Bombay and Delhi regions are said to have a capacity of 2.5 lakh tonnes and could easily consume 25,000 M.T of edible flour at 10% level fortification. Therefore, the current requirements of edible flour in the country could be placed at 50,000 M.T., which would be fully met and only the balance quantity be converted into commercial soymeal.

As for the oil, it is not recommended that it should be used in the manufacture of refined cooking oils. The oil could best be used in the Vanaspati Industry (vide Sl.No.12 below).

4. The soybean processing complex is planned on modern lines with wagon tipler, rail and truck weigh bridges, silo bulk storage and mechanical handling equipment, preliminary cleaning and drying of the beans before storage, full range of modern cleaning equipment for obtaining perfectly cleaned beans for edible products, complete preparation, extraction and meal finishing equipment with auxiliaries and accessories. Such a sophisticated set-up appears to be justified for capacities of 250 Tonnes/24 hours and above.

5. The compelling necessity of utilizing most modern machinery and technology in the processing of soybeans has to be reconciled with the equally important consideration of minimising expenditure in foreign exchange. After matured deliberation, the import of the following equipment is necessary and recommended:-

a) Complete range of modern cleaning equipment - as is supplied by M/s. Forsberg Inc., U.S.A.
b) Hydraulic Flakers - as is supplied by M/s.Ross Machine and Mill Supply Plant, U.S.A.
c) Extractor of 500 T/24 hrs. (vide Sl.No.18 below). The choice would lie between Crown Extractor and French Stationary Basket Extractor. Judging from the prices furnished by both the manufacturers, the Crown Extractor is substantially less expensive - in fact over 30% less expensive. Besides, Crown appear prima facie willing to have the extractor manufactured in India to the extent possible subject

to reasonable terms being offered. Therefore, Crown Extractor is recommended.

d) Automatic Bagging and Sewing machinery for packing - as is supplied by M/s.Howe Richardson Scale Company, U.S.A.

e) In the silo storage section, large capacity continuous bean drier would have to be imported - as is supplied by M/s.A.T.Ferrel & Co., U.S.A.

A list of the above imported machinery with prices is furnished in Exhibit 'J'. The total Cif value for the 250/500 T plant is estimated at $240,000 or Rs.1,800,000, which works out to 17.69% of the total machinery cost of Rs.10,170,600. For an important Food industry, this modest investment of foreign exchange in the first plant is fully justified, especially because the export earnings of one year's output of soymeal will earn over Rs.40 million in foreign exchange. If the overseas suppliers are persuaded to manufacture their equipment in India, the foreign exchange cost will be very much lower - nearly 50%.

The rest of the equipment could be procured from indigenous sources.

6. The total estimated Block Investment for 500, 250 & 100 T plants is Rs.27.25 million, Rs.19 million and Rs.10 million respectively. The details were worked out for 250 T plant and extended to 500 and 100 T plants. The 'Budget Forecast' presented herein carries the details.

7. An analysis of the Block Investment is presented in a chart. A glance at the chart reveals that the silo storage section (including mechanical handling equipment, bean drier, etc.) is the largest single item accounting for 42.5% of the total

block in the case of 500 T plant, 34.5% in the case of 250 T plant. The basic soy plant and utilities amount to only 28.6% and 30.5% of the total block respectively.

8. The operating costs of the plant are broadly classified under Pro-rata charges and Fixed charges. Details of the same for all three capacities are furnished herein. Also presented are charts analysing the pro-rata and fixed charges for all three capacities.

9. The Feasibility Forecast presents operational results for all three capacities. The product recoveries are based on average figures kindly furnished by the French Oil Mill Machinery Company, U.S.A. The forecast is based on bean price of Rs.1000/- per tonne FOR/FOL factory, Rs.3500/- per tonne for the oil and Rs.670/- per tonne for commercial 45% meal. The calculation based on which the ex-factory meal price has been worked out is also furnished.

10. On the above basis, the return on total Block Investment is estimated at 34.12%, 16.57% and 4.05% for 500, 250 & 100 T plants. It appears that sophisticated silo storage, mechanical handling and other equipment is too expensive for 100 T plant.

11. When edible defatted soy flour is produced, the operational picture is naturally much better because edible soy flour is a high priced commodity. In relation to the price at which the Food Corporation of India is purchasing so-called edible groundnut flour, the price of edible soy flour could be atleast Rs.1.25 per Kilo. Even calculating @ 80 Paise per Kilo, and taking into account 6% loss in weight in the meal

owing to elimination of hulls, the return on Block Investment improves to 56%, 32.36% and 16.05% for 500, 250 & 100 T plants.

12. If the price of edible soy flour is fixed at Rs.1.05 a Kilo (by no means an unreasonable figure), the ex-factory price of soybean oil can be reduced to Rs.2500/- per tonne without upsetting the profitability of the processing complex. It would then be possible for the Vanaspati Directorate of the Ministry of Food and Agriculture to continue regulation of vanaspati prices at reasonable levels using indigenously produced soybean oil in the place of the imported oil. This would mean an important measure for price stabilisation of an essential article of food.

13. The chart entitled 'Return on Block Investment' appended hereto presents the relation between capacities of plant and the return on block investment based on the production of edible soy flour and commercial soymeal.

14. The operating costs reflected in this Report compare favourably with the corresponding figures of the U.S.A. We are indebted to the French Oil Mill Machinery Co., U.S.A. for the information that based on five year averages for three typical plants, the direct operating costs per bushel, excluding office and management overhead and interest charges, are placed at $0.159, 0.182 and 0.226 for 500, 300 & 200 T plants, assuming an annual crush of 340 days. The above figures work out to approximately 46.47 and 56.08 for 500 & 250 T capacities. Deducting the interest charges and establishment costs from the Fixed charges presented herein, the figures on comparable basis for 500 & 250 T plants are Rs.37.62 and 49.56 per ton.

15. The Block Investment estimates presented herein also compare favourably with corresponding U.S figures, again kindly furnished by the French Oil Mill Machinery Co., U.S.A. (vide Exhibit 'A'). According to them their 500 T soybean processing plant will currently cost in U.S.A. $858,000 or Rs.6,435,000. The cost of 500 T soybean processing plant in the Budget Forecast attached hereto is estimated at Rs.5,362,800.

16. The bean unloading, drying, conveying and storage (2 million bushels or 54,500 Tons) section is estimated by French Oil Mill Machinery Co., U.S.A. at $1.5 million or Rs.11,250,000. The corresponding figure in the Budget Forecast for 50,000 Tons is Rs.11,550,000.

17. The total installed cost of 500 T plant, excluding land, service buildings, roads, fence, rail/road tracks, cost of bringing utilities to the area, fire protection and taxes is estimated by the French Oil Mill Machinery Co., U.S.A. at $3.19 million or Rs.24.4 million. On comparable basis, the estimate herein presented works out to Rs.20.9 million.

18. A perusal of the charts and forecasts appended hereto would indicate that a 500 T plant is most desirable as it offers best returns on the Block Investment. As the commercial cultivation of soybeans is still in its infancy, it may be hazardous to go in straight for a 500 T plant. In the circumstances, a 250 T plant with in-built facility for expansion to 500 T, such as larger sized extractor, mechanical transport equipment, etc., is recommended.

19. Some of the continuous solvent extraction plants in the country should be able to process soybeans with the addition of balancing equipment (vide page 125) in their plants. Basically it will be advantageous for plants located in Bombay and Calcutta regions to process soybeans because:

a) commercial quality meal could be exported conveniently from the respective ports.

b) Even if edible flour is produced, they could be consumed advantageously by the Flour Mills located in the respective regions, and

c) There are vanaspati factories in both the regions where the oil could be consumed.

20. It is perhaps not customary to dilate on the theoretical aspects of processing in a Feasibility Study of this type. The provocation for this deviation is:

a) The firm impression carried by visiting U.S specialists that the way in which soybean oil is being processed at present in the country leaves much to be desired.

b) The marked tendency of several entrepreneurs to overlook technological considerations and adopt dangerous shortcuts in the interests of mistaken economy.

c) As ultimately both the products emanating from the soybean processing industry will be destined for human consumption, proper processing standards are very important.

If the voluminous information compiled within the covers of these volumes should contribute, even in a small measure, to properly orient those involved in processing to adopt correct techniques, the effort and expense involved will be justified.

BUDGET FORECAST

(For details vide Exhibit 'H' & 'I')

	Capacity/24 hours	500 Tonnes	250 Tonnes	100 Tonnes
1.	Basic Soy Plant	5,962,800	4,562,800	1,900,000
2.	**Utilities:**			
	a) Steam	575,000	372,800	250,000
	b) Water	200,000	125,000	65,000
	c) Power	450,000	320,000	200,000
	d) Oil storage	415,000	215,000	100,000
	e) Sundries	200,000	200,000	200,000
		----------	----------	----------
		7,802,800	5,795,600	2,715,000
3.	a) Silo Storage & Meal handling equipment	4,050,000	2,800,000	1,500,000
	b) Railway siding & Shunter	1,200,000	1,200,000	1,200,000
	c) Weighing Equipment	375,000	375,000	375,000
		----------	----------	----------
		13,427,800	10,170,600	5,790,000
4.	**Provision for**			
	a) Sales Tax	330,000	250,000	173,700
	b) Packing, Forwarding and Transportation	200,000	149,400	80,000
	c) Heat Insulation	140,000	100,000	50,000
	d) Erection and commissioning	1,000,000	800,000	500,000
		----------	----------	----------
		15,097,800	11,470,000	6,593,700
5.	**Civil Works**			
	a) Silos	7,500,000	3,750,000	1,500,000
	b) Land & Buildings	3,000,000	2,500,000	1,200,000
6.	**Miscellaneous**			
	a) Engineering	700,000	500,000	300,000
	b) Contingencies	702,200	530,000	306,300
	c) Promotional and Admn.Expenses	250,000	250,000	100,000
		----------	----------	----------
7.	TOTAL BLOCK INVESTMENT	27,250,000	19,000,000	10,000,000
8.	WORKING FUNDS	50,750,000	26,000,000	11,000,000
		----------	----------	----------
9.	TOTAL FINANCE ...	78,000,000	45,000,000	21,000,000
		==========	==========	==========

FEASIBILITY FORECAST

	Capacity/24 hours	500 Tonnes		250 Tonnes		100 Tonnes	
		Rs		Rs		Rs	
1.	Soybeans @ Rs.1000	500,000		250,000		100,000	
2.	Pro-rata charges	9,000		5,500		2,750	
3.	Fixed charges	28,000		18,000		9,500	
4.	Packing charges @ Rs.30	15,000		7,500		5,000	
		552,000		281,000		115,250	
5.	Soybean oil - * 18% recovery @ Rs.3500		315,000		157,500		63,000
6.	Meal - 80% @ Rs.670		268,000		134,000		53,600
7.	BENEFIT PER DAY	31,000		10,500		1,350	
8.	TOTAL	583,000	583,000	291,500	291,500	116,600	116,600
9.	Benefit per annum of 300 working days	Rs.9,300,000		Rs.3,150,000		Rs.405,000	
10.	Return on Block Investment	34.12%		16.57%		4.05%	

* P.T.O.

* PRODUCT YIELDS (Courtesy: French Oil Mill Machinery Co., USA)

Oil (5% Refining loss)	...	11 lbs/Bu	(Bu = 60 lbs)
Meal (50% Protein)	...	44 lbs/Bu	
Hull	...	4 lbs/Bu	

Ex-factory price of Soybean Meal
Commercial

According to the figures published by the "Public Ledger", London, the average ruling price of Soybean Meal in London Market during the 24 month period ending 30-6-1970 is £ 50.48 c.i.f.

or Rs.908.64

LESS:	Rs	
1. Ocean freight	163	
2. Weight difference to Long ton	12	
3. Insurance	2	
4. Supervision & inspection at destination	2	
5. F.O.B. expenses	15	
6. Freight, etc. Factory to Port	30	
		Rs.224.00
		Rs.684.64
7. Provision for contingencies		Rs. 14.64
Ex-factory price ..		Rs.670.00

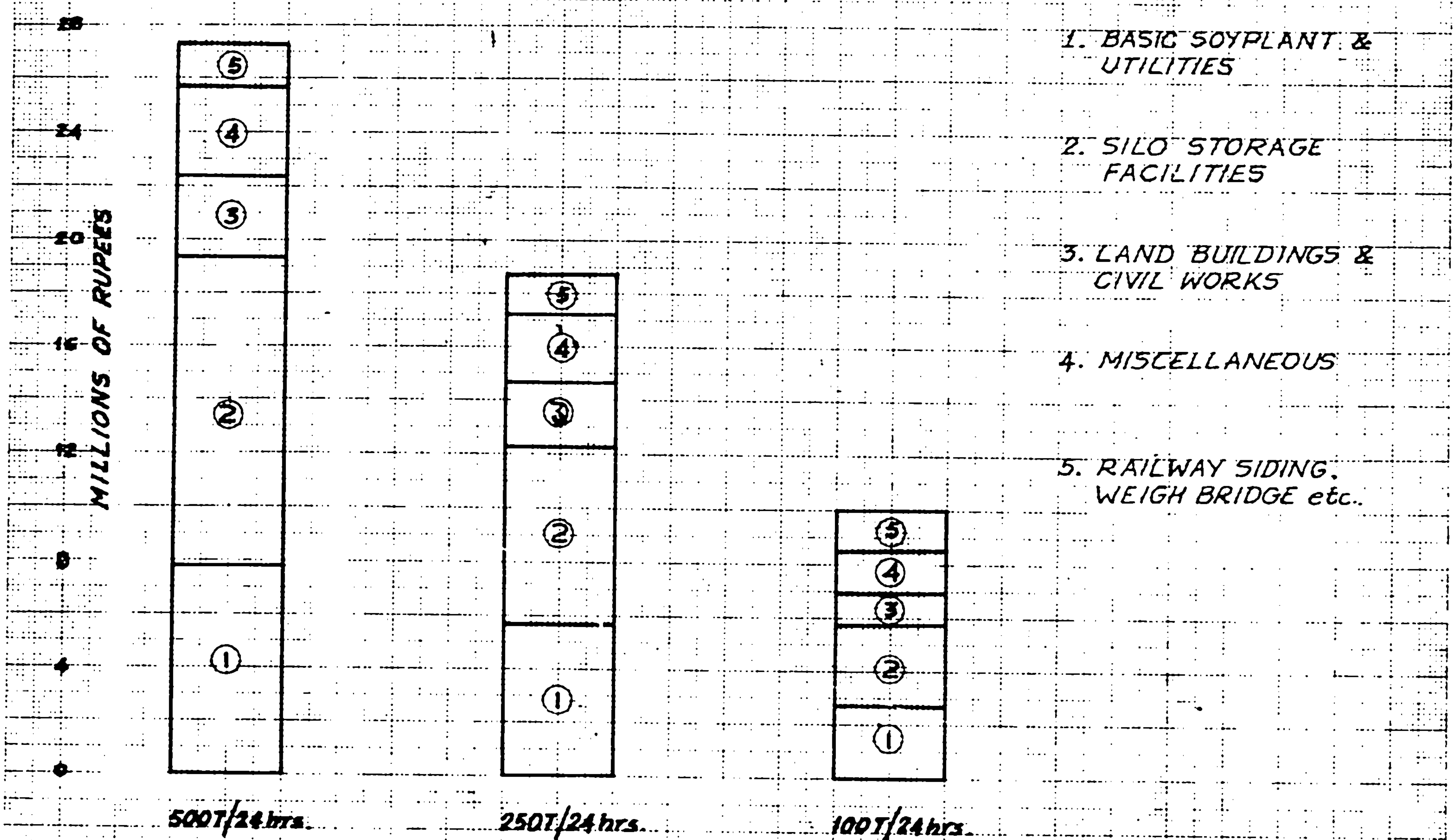
PRO-RATE CHARGES

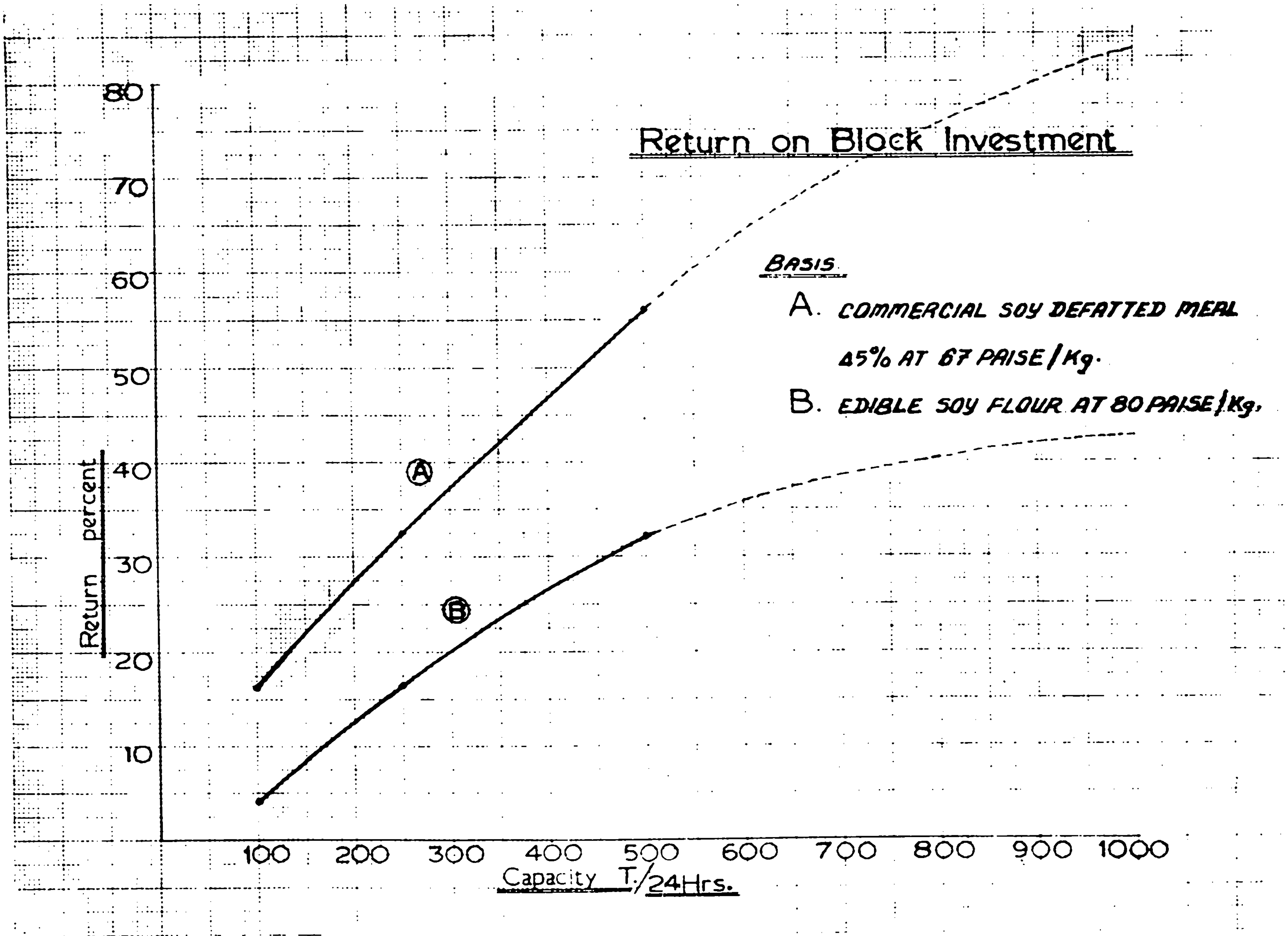
	Capacity/24 hrs.		500 Tones Rs		250 Tonnes Rs		100 Tonnes Rs
1.	Solvent consumption	2500 Kgs @ Rs.1	2,500	1500 Kgs @ Rs.1	1,500	700 Kgs @ Rs.1	700
2.	Steam consumption	150 Tons @ Rs.20	3,000	90 Tons @ Rs.20	1,800	40 Tons @ Rs.20	800
3.	Power consumption	20,000 KwHr @ 0.1	2,000	12,500 KwHr @ 0.1	1,250	6,000 KwHr @ 0.1	600
4.	Operating Labour						
	9 Operators	@ 20	180		180		180
	15 Assistants	@ 15	225		225		225
5.	Handling	@ Rs.2	1,000	@ Rs.2	500	@ Rs.2	200
6.	Sundries		95		45		45
7.	PER DAY	....	9,000		5,500		2,750
8.	PERTON	....	18		22		27.5

FIXED CHARGES

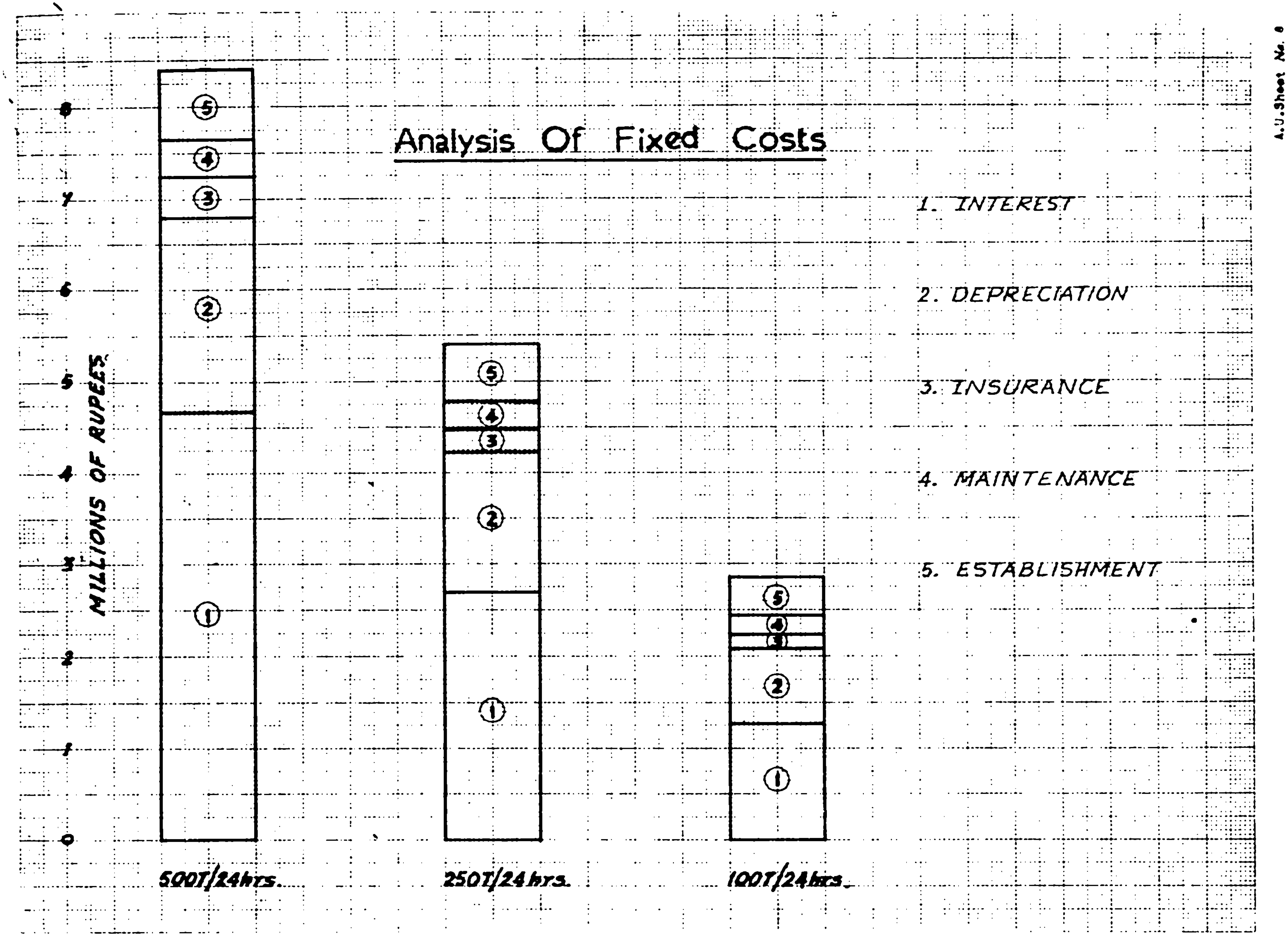
	Capacity/24 Hrs.	500 Tonnes	250 Tonnes	100 Tonnes
1.	Depreciation	Rs	Rs	Rs
	10% on Plant & Machinery	1,489,780	1,150,000	659,370
	5% on Bldgs & Civil works	617,610	375,000	170,315
2.	Interest @ 6%	4,680,000	2,700,000	1,260,000
3.	Maintenance	400,000	300,000	200,000
4.	Insurance	468,000	250,000	132,600
5.	Establishment	744,610	625,000	427,715
6.	PER ANNUM	8,400,000	5,400,000	2,850,000
7.	PER DAY	28,000	18,000	9,500
8.	PER TON	56	72	95

Analysis Of Block Investment

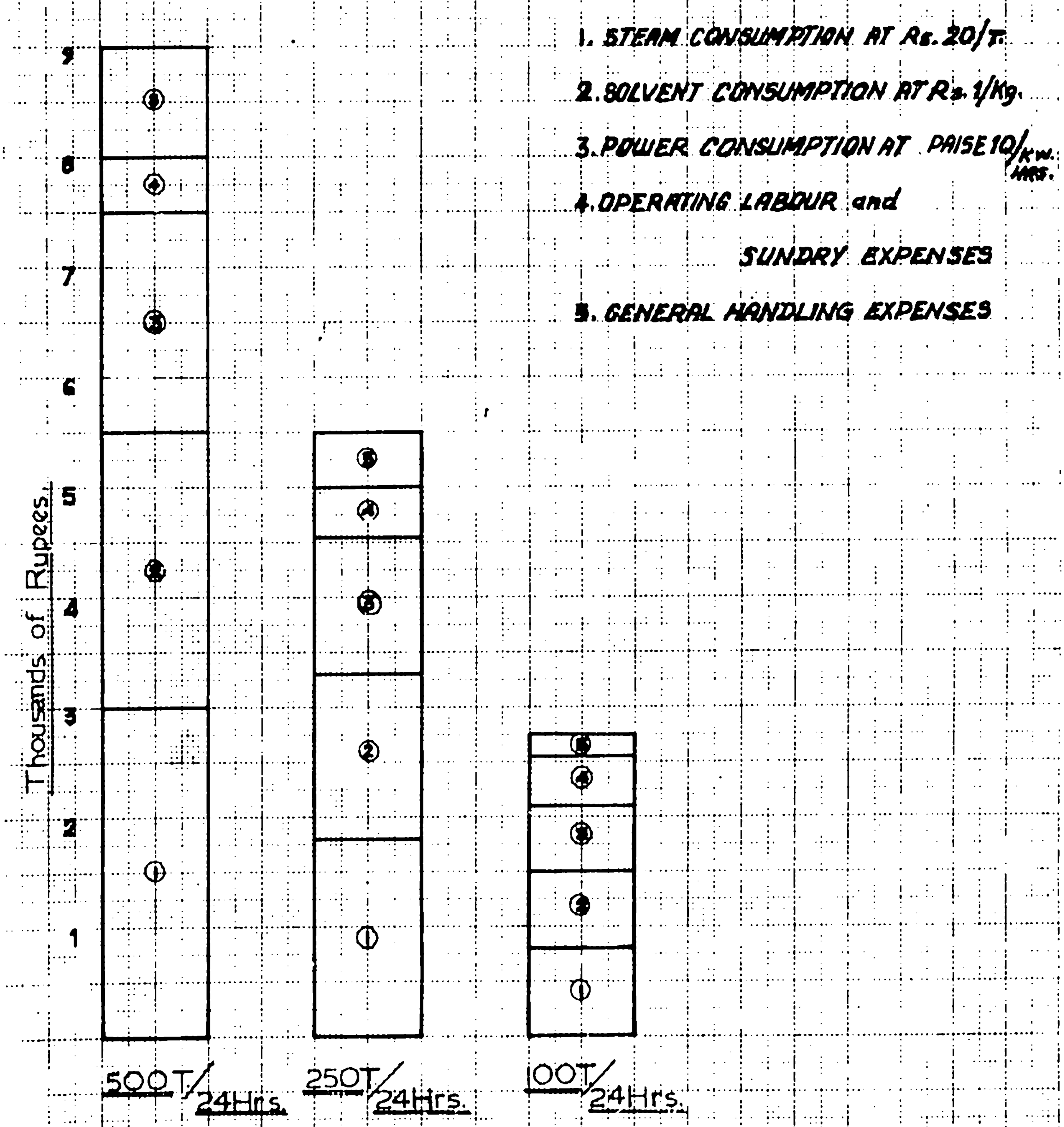



Return on Block Investment
BASIS
A. COMMERCIAL SOY DEFATTED MEAL 45% AT 67 PAISE/Kg.
B. EDIBLE SOY FLOUR AT 80 PAISE/Kg.
Return percent
80
70
60
50
40
30
20
10
100
200
300
400
500
600
700
800
900
1000
Capacity T./24Hrs.
A
B

A.U. Sheet No. 8


Analysis Of Fixed Costs
MILLIONS OF RUPEES
0
1
2
3
4
5
6
7
8
1. INTEREST
2. DEPRECIATION
3. INSURANCE
4. MAINTENANCE
5. ESTABLISHMENT
500T/24hrs.
250T/24hrs.
100T/24hrs.
A.U.Sheet No. 8

Analysis Of Pro-rata Operating Costs.



PREFACE

1. In the introduction of Soybean into Indian Agriculture the USAID has played a very significant role. This Technical Feasibility Study for processing soybeans is also compiled under contract from the USAID. It is intended to place at the disposal of entrepreneurs all the required information for providing processing complexes for soybeans.

2. A study of this magnitude should normally take six months to be completed. Owing to a variety of reasons, it had to be compressed into about three months. Should there be any inadequacy or inaccuracy in any part of the Report, the very short time permitted is an extenuating circumstance.

3. Soybean is still new in India - perhaps none in the country has actual in-plant experience in processing this material. Reliance had perforce to be made on published information, data supplied by well-known Firms and discussion with visiting experts. Preclusion of foreign travel in the terms of the assignment was a great handicap indeed.

4. Many foreign and Indian Firms were unenthusiastic in furnishing detailed quotes. The former, conditioned by past experience, are pessimistic of business possibilities in India. The latter, perhaps, felt this is an academic exercise. Our thanks are, therefore, doubly due to those who did co-operate, viz. Messrs.Aeroglide Corporation, North Carolina., Messrs.Campbell Industries Inc., Des Moines., The Crown Iron Works Company, Minneapolis., Messrs. Du-Val I.F.T. Corporation, Dallas, Texas., Messrs. A.T.Ferrell & Company, Michigan., The Forsberg Inc., Minnesota., The French Oil Mill Machinery Company, Piqua., Messrs.Lowe Richardson Scale Co., Clifton, New Jersey., Messrs.Huntley Manufacturing Company, New York., Messrs.Proctor & Schwartz Inc., Philadelphia., Messrs.Ross Machine and Mill Supply, Oklahoma City., Messrs.Superior Welding Company, Illinois., all from U.S.A. and others.

5. SERVOTECH also manufacture complete range of modern equipment for solvent extraction, vanaspati, etc. As a matter of principle and ethics, no reference is made to them in the discussion on relative merits of equipment.

6. Reference to Trade names and Firms in this Report should be deemed to be illustrative and not exhaustive or exclusive.

7. Layout and general arrangement drawings should be considered as typical and illustrative only. Each project has to be engineered individually to suit its specific requirements and conditions.

8. We are indebted to Mr.Harold D.Missler, Jr., Oilseeds Processing Advisor, USAID, for his valuable guidance and unstinted co-operation which has been of great help in conducting this Study.

9. This Report is presented in two volumes:-

i) Volume I contains Introduction, Basic Soybean Processing, Equipment for processing, Location of Plant, Finance & Feasibility Forecasts, Typical flowsheets, Site-Plan, Layouts and charts.

Volume II contains the theory and basic Technology of processing the oil and the manufacture of various food products.

ii) This facilitates easy handling of the Report by the users. While Business Executives and Policy Makers study Volume I, their Technical staff can go through Volume II.

iii). Volume I relates to the first phase of Soybean processing in the immediate future. Volume II deals with the subsequent phases.

10. Opinions expressed and recommendations made herein are born out of honest conviction, free from prejudice or malice. No offence is meant or implied towards anyone.

I. INTRODUCTION

Soybean in the national economy

One of the primary responsibilities of a progressive State is to ensure that its citizens are well fed. Despite the fact that India has been a predominantly agricultural country, traditional agricultural practices, patterns and produce have proven to be inadequate to provide food for the population, currently placed at 550 million and increasing at an alarming rate. The quest for a solution to this pressing problem has focussed attention on Soybean. After intensive development work, soybean has made its appearance in the agricultural horizon of the country at the turn of the decade.

Intensive Agricultural District Programmes, high yielding varieties of seeds, scientific application of fertilizer and pesticides and modern farm practices - collectively referred to as 'Green Revolution' in the country - show promise of meeting the calorie requirements of the population. The problem of balanced diet and malnutrition of the masses still remains to be tackled.

Soybean - one of the best source material for protein.

Protein is an essential constituent of a balanced diet and is particularly important for children, expecting and lactating mothers. Protein deficiency during the period of rapid growth and development is known to be directly related to high morbidity and mortality rates. The most devastating effect of inadequate protein in the diet of infants and children is perhaps on the brain, the growth of which is retarded during the formative period resulting in almost irreparable damage. Resistence to infection is also believed to be reduced to minimal level by protein deficiency.

There is, therefore, an obvious and urgent need for finding a suitable source material for protein which could be used as a supplement in conventional diets. Obviously, low cost is an important factor. Oilseeds, like groundnut and cottonseed, contain a high percentage of protein which could possibly be used for edible purposes. However, aflotoxin infection in the case of groundnut and the presence of gossypol in the case of cottonseed pose problems which have to be satisfactorily solved before this valuable source material could be tapped. Soybean, which contains about 40% protein, presents no such problem in processing and should, therefore, be the first choice for the manufacture of edible proteins.

Balanced Amino-Acid Pattern.

Research has revealed the importance of certain amino-acids for health and well-being of humanbeings. From this point of view, the amino-acid configuration in Soy Protein is eminently suitable for diet supplements. The following amino-acid composition of Soy Protein and Groundnut Protein illustrates the point:

		Soybean Meal	G.Nut Meal
Lysine	Grams/16g N	7.0	3.0
Methionine	-do-	1.5	1.0
Arginine	-do-	7.6	11.3
Histidine	-do-	2.8	2.1
Iso-Leucine	-do-	5.7	4.6
Leucine	-do-	7.8	6.7
Cystine	-do-	1.7	1.6
Phenyl-Alanine	-do-	5.1	5.1
Theonine	-do-	4.0	2.7
Valine	-do-	5.2	4.4
Trystophan	-do-	1.3	1.0

A study of the above table would reveal that soybean meal is superior to groundnut meal in 9 out of 11 amino-acids enumerated. Lysine is considered essential for growth and soybean meal contains 130% more of this important amino-acid than groundnut meal. With regard to the important amino-acids containing sulphur - Methionine, Cystine - soybean meal is well balanced.

Apart from the composition of amino-acids, the P.E.R. Value (Protein Efficiency Ratio), which is a yard-stick used for assimilation of proteins taken into the system, soybean meal is superior with 1.85 as against 1.48 of groundnut meal. Even the protein isolate from groundnut meal is said to have a P.E.R. Value of 1.62 only. This is yet another important factor in favour of soybean. Another interesting fact is that while soybean meal alone can be fed to animals as a balanced feed, groundnut meal does not lend itself to such exclusive use. Indeed, soybean is at present acknowledged to be the best known source of protein in the Vegetable Kingdom.

More oil per acre despite lower oil content.

Notwithstanding the fact that India has been considered to be one of the largest producers of oilseeds in the world, and not too long ago it was exporting oilseeds, acute shortage of edible fats has been evident in the country during the last decade necessitating import of soybean, cottonseed and sunflower oils at considerable expenditure of foreign exchange. Widespread cultivation of soybean, apart from its importance in making up protein deficiency in the diet of the masses, can also play a very useful role in alleviating the shortage of fats. Though the oil content of soybean may be considered low, about 20%, when compared to conventional oilseeds like groundnut, the interesting fact emerges that more oil can be obtained per acre with soybean than with other oilseeds, thanks to the spectacularly higher yields. Further, the fact that soybean could be grown all over the country, on hills and plains, even in tracts where other oilseeds cannot be grown, is very significant and deserving attention. The substantial imports of soybean oil at considerable expenditure of foreign exchange could be eliminated by cultivation of soybean in the country on a large scale.

Foreign Exchange earner too.

Apart from the negative aspect of saving foreign exchange, soybean could be a positive exchange earner too. For some time to come, till processing facilities for food products are created and market development work reaches a satisfactory stage, defatted soy meal would have to be exported. Fortunately, soy meal has a ready and virtually unlimited market overseas as it is the most preferred meal for feeding stuffs. Therefore, one of the incidental advantages of extensive cultivation of soybean will be a welcome addition to the foreign exchange earnings of the country.

Welcome alternate raw material for processing industries.

Plan Forecasts highlight the increasing requirements of vanaspati during the coming years. It is generally believed that one of the main impediments to the rapid expansion of the Vanaspati Industry is the non-availability of edible oils at economic prices. Large scale cultivation of soybean holds promise of meeting the requirements of the second largest food processing industry of the country at reasonable prices. The Vanaspati Industry has been using and appreciating soybean oil for the last few years. It is, therefore, in a position to absorb all the soybean oil that may be produced in the country in the foreseeable future.

There has been a rapid development of the Solvent Extraction Industry in the last decade. For a variety of reasons, substantial part of the capacity of this Industry is said to be unutilised. The availability of soybeans in quantity in the coming years would indeed be a boon to the Solvent Extraction Industry, as it would enable not only the full utilisation of existing capacity but justify its rapid expansion.

It would be evident from the foregoing that the golden bean of the century has indeed a very important role to play in the coming years. It is not inconceivable that soybeans may overshadow, in course of time, all other oilseeds in the country, as it has done elsewhere in the world.

Areas where Soybeans are grown.

It is expected that during the next Kharif season about 1,50,000 acres will be brought under soybean crop, the Statewise distribution being as follows:-

Uttar Pradesh	60,000	acres
Madhya Pradesh	20,000	"
Gujarat	20,000	"
Maharashtra	15,000	"
Punjab	10,000	"
Other States	25,000	"
Total	1,50,000	"

Assuming even a modest yield of 6 quintals, the total production will be of the order of 90,000-metric tonnes, which is expected to increase in 1971 to 3.2 lakh tonnes.

Soybean cultivation is at present prevalent in:

Nainital, Kanpur, Varanasi and Hardoi regions of Uttar Pradesh.

Jabalpur and Indore regions of Madhya Pradesh.

Junagadh and Navsari regions of Gujarat.

Amraoti and Poona regions of Maharashtra.

Ganganagar area of Rajasthan.

Bangalore and Dharwar regions of Mysore.

Coimbatore region of Tamil Nadu.

Pusa region of Bihar.

Cuttack region of Orissa, and

Kalyani region of West Bengal.

Apart from soybean cultivation on the plains, it is also being grown on the Northern Hills:

Majhera and Almora in Uttar Pradesh.

Nagroti and Solan in Himachal Pradesh.

Kalimpong in West Bengal.

Also Katrain, Palanpur, Kangra, Kavalbaugh, Pauri, Garhwal and Ramgarh.

REVIEW OF OILSEED PROCESSING IN INDIA.

Rotary 'Ghani'

One of the earliest attempts at organised oilseed processing is the rotary 'Ghani' which is, in principle, a simple mortar and pestle arrangement. In the initial stages, the pestle was rotated by a pair of bullocks; subsequently the bullocks gave way to an electric motor. By virtue of simplicity in design and maintenance, the 'ghani' is very well suited for decentralised and self-contained village economy. As processing conditions are mild, the quality of oil and cake produced is very good. However, from the oil recovery point of view, this arrangement is very inefficient as the residual oil content in the cake is 15% or more. In days of yore and plenty, this might have not mattered, but in the context of present-day shortages it matters a lot. The rotary 'ghani' is still very much in vogue especially for the crushing of mustard seed in the North and copra in the South. It is still believed by the Industry that the element of pungency in mustard oil which is very important in its marketing, is more pronounced in the oil obtained from the 'ghani' than in the expeller. In the case of copra, where a very light colour is of prime importance, the rotary 'ghani' is still in vogue. However, the 'ghani' is slowly but surely is bowing out in favour of the expeller.

Screw Presses

The expeller has been more efficient from the point of view of oil recovery as the residual oil left in the cake is about 6 to 7%. Even to this day there are many who believe oil milling is only a matter of expellers. The necessary seed preparation, which is considered a must from the point of view of modern technology, is absent in the vast majority of mills.

Seed Cleaning

The first step in processing should necessarily be proper cleaning of the seed to rid it of all foreign matter. A magnetic separator is essential to trap tramp iron and prevent damage to costly equipment. Twigs, leaves, dirt, etc. are discarded by a combination of vibrating screens and aspirating devices. The importance of proper seed cleaning for achieving purity of products, especially when they are destined for edible use cannot be overemphasised.

Importance of cooking the seed.

If one should study the literature supplied by world-renowned specialists in oil milling like Krupps of Germany, Rosedown of U.K., or French Oil Mill Company of U.S.A., the importance of proper cooking of the seed before expelling is emphasised. The reasons are not far to seek; cooking serves several functions:

1. It ruptures the oil cells and creates conditions in which the oil can ooze out easily with minimum pressure.

2. It increases the fluidity of the oil by an increase in temperature.

3. It coagulates or granulates the protein aleurone grains. This facilitates separation of the oil from the proteinaceous and other materials.

4. It 'precipitates' phosphatides and produces oil of lower refining loss.

5. It destroys moulds and bacteria.

6. Additionally for cottonseed, it detoxifies free gossypol by converting it to the 'bound' form.

7. It inactivates enzyme systems which have adverse effects on the quality of oil and meal; especially important for improperly stored seed.

In our own country the effect of controlled cooking was carefully studied in the oil Technologists' Research Institute, Anantapur, and the results of pilot plant studies were published in the Indian Oilseeds Journal, Vol.8, No.1, 1964 by Messrs. Kutumba Rao, S.D.Thirumal Rao, M.Allah Baksh and K.S.Murti. They have established that:

1. Too low moisture in the seed makes it brittle and 'tacky', not conducive to develop pressure in the expeller. Large amounts of 'fines'

pass into the oil and the yield of filter mud is highest. The colour of the oil is also darkest.

2. On the other hand, where there is excessive moisture, there is slippage or 'crawling' in the expeller and the crushing time per ton of seed is highest. Choking in the feed end due to premature release of oil was also noticed.

3. When cooking temperature was too low, more sediment was found in the oil.

4. With high temperature, the oil turned dark.

5. Optimum conditions for best results are: Cooking for about 15 minutes at 100/105°C with initial moisture content before cooking of 6-8% and final moisture content of 4-5% before entering the expeller.

Oil millers would do well to consider these facts.

There is general impression that the small tempering worm attached to the expeller is adequate for cooking; this is by no means the case. It will be well nigh impossible to regulate the temperature and time of cooking and the moisture content within the prescribed limits. Besides, with a large number of expellers, it will be unrealistic to be able to control cooking at all the expellers simultaneously. A central Cooker-Conditioner for the total tonnage involved is the best solution.

Cracking the seed

With the seed in tact, proper cooking and moisture control would be very difficult. Cracking the seed into small bits before cooking greatly facilitates operations. Cracking the seed also serves to increase remarkably the tonnage that an expeller can handle. The expeller cage has a certain volume; much more cracked seed can be accommodated in a given volume than the full seed itself. It has been demonstrated that the throughput of an oil mill can be increased by over 50% by proper cracking and cooking alone.

Disposal of foots

The oil emerging from the expeller contains some suspended solids derived from the original seed. In conventional oil mills, this oil is settled in several underground tanks before it is filtered. This arrangement is technically undesirable because:

1. Prolonged contact between the 'foots' and the oil results in increase in F.F.A. and deterioration in the colour of the oil.

2. Periodical removal of the settled sludge is necessary which requires shut-down of the oil mill and loss of production.

3. The accumulated sludge cannot be fed back to the expellers all atonce as it will upset the operation of the expellers owing to its slimy nature.

4. When the aged sludge is fed back to the expellers, it impairs the quality of the oil and cake and reduces the efficiency of the expellers.

5. A lot of manual operations are involved.

6. All this makes the premises messy and dirty.

7. Not infrequently rats, cats, dogs, etc., find their way into the underground tanks resulting in contamination of the edible product - from the hygienic point of view, the arrangement is intolerable.

8. There is unnecessary loss of oil in the messy handling operations and through invisible seepage through the masonry tanks.

In modern oil mills, the underground tanks are totally eliminated and the suspended solids in the oil are continuously separated by rotary or vibration screens and the recovered solids returned immediately to the expellers.

Solvent Extraction

Oil milling techniques referred to supra are based on mechanical expulsion of oil from the parent seed. The conditions of temperature and pressure existing in the expeller are such as to impair the valuable protein content in the screw pressed cake. Not infrequently the colour of the oil is also affected, a notable example being cottonseed oil. Whereas in the years gone by oil was considered the main product and the oil-cake a subsidiary product, the time has come when the protein-rich oilcake should be considered atleast as important as the oil itself.

The advent of solvent extraction has ushered in a new era in oil milling all over the world. Unlike earlier processing techniques which depended on brute force in the recovery of oil from the seed, in the extraction process the oil is dissolved in a solvent and recovered from the parent material. Conditions of processing are relatively mild and congenial to obtaining quality products. The residual oil after extraction can be brought down to as low as half a percent.

The modern trend in advanced countries of the world is to have an oil mill and an extraction plant under one roof. Milling conditions with screw presses are so regulated that pre-pressed cake of 16-20% oil content is obtained. Under those conditions, there is no damage done either to the protein or to the oil. The resulting pre-pressed cake, after suitable preparation, is immediately and continuously processed in a solvent extraction plant to recover the last traces of oil. It is high time that such an approach to the processing of oilseeds is adopted in this country as well in order to obtain best results and prime quality products.

Soybeans which contain about 20% oil could be pre-pressed with screw presses and solvent extracted thereafter, but the better course is to handle the beans directly in the solvent extraction plant. This procedure is almost universally adopted in all advanced countries of the world.

BASIC SOYBEAN PROCESSING.

Outline of the Process.

Processing of soybeans for the recovery of oil and manufacture of commercial quality defatted meal involves the following basic sections :

Preparation

Extraction

Desolventisation of Marc

Finishing of Meal

Evaporation of Miscella
and
Recovery of Solvent.

The beans, when received at the factory, have to be separated from all foreign matter; ferrous impurities are separated by magnetic separators while dirt, trash, etc., are eliminated by cleaning equipment. The cleaned beans are cracked, during which operation the hulls separate and are recovered pneumatically. The beans are conditioned and flaked before being delivered to the extractor.

In the extractor, the flaked material is treated with solvent and, at the end of the extraction process, wet marc and miscella are obtained.

The wet marc is desolventised in a Desolventiser-Toaster after which the meal is ground to size, cooled and packed into bags.

The miscella obtained from the extraction section is evaporated for separation of oil and solvent. The oil is finally stripped of all solvent, cooled and delivered to storage.

Solvent vapours from the entire plant are recovered in water-cooled condensors. The condensate is a mixture of solvent and water, which are separated in a water-solvent separator. The solvent is returned to storage while the water is finally stripped of all traces of solvent in a flasher before it is allowed to leave the plant. The uncondensed gases may still contain some solvent and this is recovered in a special recovery system. The solvent-free air is vented into the atmosphere.

CLEANING & PREPARATION OF SOYBEANS.

In most processing industries, proper preparation of the raw material is a very important requirement influencing the purity of finished products obtained and the efficiency and economy of operations. Soybean processing is no exception to this general principle.

Being an agricultural produce, the beans that arrive at the processing factory is likely to contain foreign matter such as leaves, twigs, dust, stones, nails, etc. These foreign materials have to be eliminated before the regular processing starts; otherwise expensive equipment is liable to be damaged and the purity of the finished products impaired.

Cleaning of Soybeans.

Before entering the cleaning equipment, the beans are passed over a magnetic separator which eliminates tramp iron which may be present in the stock. Magnetic separators may employ either permanent magnets or electro magnets. Drum type electro magnets appear to be preferable because the iron materials which may be arrested are automatically discharged into a bin provided leaving the passage for the material free. In the case of permanent magnets, the impurity gets attached to the magnet and requires external agency for its removal. Besides, when a lot of impurities accumulate on the surface of the magnet, it does obstruct the flow of material. The strength of the magnetic field is generally much higher with electro magnets and, therefore, separation of tramp iron is more effective.

Complete cleaning for edible products.

A modern practice in the U.S.A. achieves perfectly cleaned seeds by employing a 4-stage cleaning equipment, each of the stages performing a specific function. The first stage, generally known as 'Pneumatic Scalping' is intended to remove light impurities such as trash, dust, chaff, leaves, straw and pods. The air-washed product, which incidentally is thoroughly aerated, passes on to the second stage. The equipment for the second stage is essentially a system of vibrating screens; the beans pass through the perforations of the top screen while larger impurities pass over and are eliminated. On the lower screen the perforations are too small for the beans to pass through but finer particles of foreign matter get through and are discarded. The beans roll down the lower deck and at the discharge point encounter a current of air which lifts light impurities. The aspiration arrangement will also lift inferior quality beans which will be lighter in weight.

Destoner. The third stage is the Destoner, the purpose of which is to remove all stones, metal, glass and other foreign materials that may happen to be present in the stock. This is achieved by allowing the material to pass down an inclined vibrating screen and a current of air is made to pass through the screen by means of vacuum. The air flow is said to hold the material in 'stratified flotation'. Heavier materials such as stones, glass, etc., travel up the screen and are eliminated. The product itself flows down the screen and at the discharge end of the deck the bottom portion of the bed consists of gravity pure finished product while the top portion contains the lighter impurities for further purification.

Gravity Separator. The top material referred to in a preceding paragraph is received on a gravity separator, which is the last stage of the series. The purpose of the gravity separator is to eliminate foreign materials which are of the same size as the beans, the separation being achieved by taking advantage of the difference in specific gravity.

Abridged cleaning for commercial meal.

The foregoing 4-stage cleaning process yields a perfectly cleaned product which is for ultimate edible use. Such elaborate cleaning may not be necessary for commercial quality soymeal. It is customary to use a single cleaning machine with vibrating screens and aspiration arrangement for cleaning beans destined for the manufacture of commercial quality meal. It is said to be the practice in the U.S.A. that the materials recovered during the various stages of cleaning, except for metallic impurities and stones, are ground and added back to the commercial quality defatted meal, in order to minimise weight loss.

PREPARATION OF BEANS:

Cracking.

The cleaned beans have to be cracked approximately to 8 pieces by cracking machines which are essentially corrugated roller mills operating at differential speeds. During the cracking operation, the husk adhering the bean is loosened. The mixture of beans and hulls can be used as such without separation when the end-product desired is commercial quality 44% meal. However most processors prefer broad separation of the hulls from the cracked beans before the conditioning and flaking steps. In such an event, the hulls which are separated are either ground, toasted and added back to the defatted meal in the finishing section or are fed back to the main stream after the flaking operation.

When high protein 50% meal is desired or when the end-product is used for human consumption, separation of the hulls from the beans is essential. A 'Pneumatic Scalper' (referred to above) is generally adequate for separation of hulls for high protein 50% meal. For edible products, however, the air-washed beans are handled on gravity separator for the elimination of last traces of hulls.

Conditioning. The cracked beans need to be conditioned before they are flaked. The conditioning step is intended to soften and plasticise the material which is achieved by increasing the moisture content to about 11% at a temperature of 70 to 80°C.

Flaking. The conditioned beans are passed through a Flaking machine, whose purpose is to flatten out the material into thin and coherent flakes about 0.009 of an inch thick. The flakes are then passed on the Extractor for the recovery of oil. The flake thickness has a great influence on the subsequent extraction operation as would be evident from the following table:

Effect of Flake Thickness on the Rate of Extraction by Hexane. *

1. Extraction time in minutes to a 1% residual oil content:

Flake thickness (inches)	0.009	0.014	0.017	0.022
Time of extraction(minutes)	5	12	25	70

2. Residual oil content(%) after various times of extraction:

Flake thickness(inches)	0.009	0.014	0.017	0.022
% Residual oil				
5 minutes ext.	1%	2.5%	5%	12%
10 minutes ext.	0.35	1	2	3.5
20 minutes ext.	0.2	0.6	1.3	2.5

Looking at the above table, five times as long a period is required to extract the flakes to a residual oil content of 1% when the flake thickness is roughly doubled from 0.009 inches to 0.017 inches.

* (H.W.FORMO, Proceedings of the All India Workshop Conference on Processing, Utilication and Marketing of Soybeans, October 7/9, 1969).

SOLVENT EXTRACTION.

Solvent extraction, as applied to the Oil Industry, is concerned with the separation of the liquid component (oil) held by a solid (oil bearing material) by treatment with an immiscible solvent in which the liquid component is soluble. The extraction process basically involves two operations: (a) bringing the solvent and the oil bearing material into intimate contact and (b) separation of the resulting phases.

<u>Leaching.</u> Basically the process of extraction is a combination of leaching and washing. Leaching refers to the diffusion of the oil through the liquid filled on the solid surface of the material under extraction. Prediction of the rate of leaching is complicated by the fact that the inter-facial area decreases as leaching proceeds. The major resistance to the diffusion of oil to the solvent occurs within the flakes. Osbourne and Katz observed that "the major obstacle to extraction is probably diffusion through the cell walls and that the initial rapid extraction is to be attributed to cell destruction." Consequently the size of the flake or particles prepared for extraction plays a

key role in the rate of extraction. The rate of simple diffusion is directly proportional to the extraction temperature. It is obvious that as the temperature rises, the viscosities of solvent in oil are lower resulting in rapid rate of extraction. In commercial practices, it has been found that a distinct relation between the particle size and the rate of extraction exists and Coates & Wingert propose the following formula:

$$T = KD^n$$

where T = Time to reduce material to a residual oil content of 1%

D = Flake thickness or grit diameter

K & n = Constants.

The relationship on log-log scale between T & D is a straight line with a slope equal to 'n'.

The constant 'K' is a measure of ease of extraction, whereas the exponent 'n' is an indication of the influence of flake thickness upon the extraction rate. Incidentally it may be of interest to know that the average value of 'n' for soybeans is between 2.3 and 2.5.

Washing. Washing is the process of removal of the solute already in solution in a liquid held mechanically by a porous solid, in this case the material under extraction.

The basic equation is the Raoult's Distribution Law:

$$y = K'x$$

where y = oil concentration in the micoella phase

x = oil concentration in the oil-bearing material phase

K' = distribution co-efficient

For most systems, however, K' varies considerably with concentration of oil in the material under process, and the relation can hardly be called a 'Law'.

Moisture. Fann and Co-workers found that higher the moisture content of the material under process, the lower the rate of extraction. In fact, the rate of extraction dropped down in an almost exponential form.

Residual Oil. During the examination of the structural configuration of the oil-bearing materials it was observed that the rate of extraction fell steeply as the original oil content in the oil-bearing material went down. Karnofsky and Co-workers have advanced the hypothesis that the slow final extraction rate could be the result of decreased solubility of the last portions of the oil. In other words, the last portions of the oil being preponderant in Phosphatides, it is possible that the apparent rate of extraction of the oil comes down.

It was found that at the lower values of the fraction of the total oil unextracted at the end of a particular time period, there is a linear relationship between the time hours and the logrithmic value of the unextracted fraction of the oil. Bailey, however, emphasises that this relationship is valid only in all flakes having the same uniform thickness. Obviously such a situation does not prevail in practical working conditions and some deviations are bound to occur.

<u>Basic considerations.</u>

The two important questions which arise when considering solvent extraction are:

a) What is the quantity of oil that can be extracted? and

b) How fast can the oil be extracted?

The first question is connected with the equilibrium or the washability aspect. The parameters, which determine the rate at which the equilibrium is obtained between the miscella outside the seed particles and the miscella within are:

1. the intrinsic capacity for diffusion of solvent and oil.

2. the viscosities of the two
3. the size and shape of the oil-bearing particles
4. the internal structure of the oil-bearing material
5. the conditions of temperature, and
6. the moisture level.

Single Contact Extraction.

The simplest form of extraction is the single contact operation in which the solvent and oil bearing material are brought together for a single batch extraction. The oil is transferred from the solid phase to the liquid phase and the concentrations in the two phases approach equilibrium eventually. The amount of oil extracted is determined by the amount of solvent employed, the period of contact, the equilibrium relation for the system and the extent to which it is possible to approach equilibrium. However, the final miscella and the marc in a single contact operation are essentially in equilibrium with each other and the amount of oil extracted with a given amount of solvent is definitely limited. The efficiency permitted by the equilibrium involved is usually poor and hence this type of operation can hardly be employed on an industrial scale.

Multiple Contact Extraction. An obvious improvement over Single Contact Extraction is the multiple contact extraction using fresh solvent in each contact. The reduction of oil content in the oil bearing material may theoretically be improved to the desired extent by increasing the number of contacts or stages of extraction. It may be seen that the concentration of miscella in later stages is low. Consequently this method of operation is uneconomical as the solvent to material ratio is high. Conventional batch type plants in the country follow this type of operation.

Counter current operation. The next logical development has been to operate a number of batch extractors in series as a battery. In this system the oil bearing material to be treated enters the first zone while all the fresh solvent enters the last zone. While the material itself is stationary, the flow of solvent is counter current and all the solvent passes through each stage and the overall efficiency for a given amount of solvent and the number of stages is appreciably better than the earlier attempts at solvent extraction.

Continuous Extraction. Dissatisfaction with discontinuous operating techniques resulted in the development of continuous counter current extraction. Theoretically maximum extraction efficiency is achieved if it were possible to obtain intimate contact between the phases in an apparatus in which the solvent and the oil bearing material are passed continuously in opposite directions.

Submerged Extraction - Hildebrandt Extractor.

This has been attempted in various ways in the earlier continuous extractors, such as Hildebrandt 'U' Tube type Tower Extractor. In such method of operation several practical difficulties were encountered. Firstly, the preparation of the raw material becomes critical for achieving good results. Secondly, the solvent-material ratio runs high. Thirdly, the material crumbles to 'fines' resulting in problems of separation of the two phases. Finally, various engineering difficulties were also encountered. Hence this system of 'Submerged extraction' was gradually discarded in favour of 'Percolation' type of extraction.

Percolation Extraction - Vertical basket type- Hansamuhle Lurgi French

Hansamuhle, unlike the earlier type of extractors, does not immerse the oilseed flakes in the solvent, but extracts by the percolation of solvent through the seed while they are held in a series of baskets with perforated bottoms. The baskets are supported by endless chain within a gas tight housing. The flow of solvent/miscella is co-current in the descending side and counter current in the ascending side.

The principal advantage of basket type extractor is that it yields clean miscella with minimum content of 'fines' because there is no mechanical disturbance to the material under process during the extraction period and the descending baskets form an effective series of filter beds. Its principal disadvantages are:

a) Distinct possibilities of channelling of solvent flow through the material with the attendant risk of part of the material passing unextracted.

b) With some type of materials, a tendency to pack in the basket and become relatively impervious to percolation is noticed.

c) Should the perforated bottom of any basket become clogged, the solvent/miscella being unable to pass through, overflows into the outer container and the lower baskets may escape contact with solvent/miscella.

<u>Percolation Extraction - Horizontal type - De Smet Lurgi French.</u>

De Smet of Antwerp, Belgium, pioneered the horizontal Extractor with a single articulated band conveyor. The material under process is itself static, but the moving band exposes the material to a series of extraction stages. The flow of solvent is continuous and fully counter current. In each extraction stage solvent/miscella is uniformly distributed over the bed by a combination of an atomiser and spray breaker. Adequate time for drainage of solvent/miscella is provided in between the extraction stages. Clean miscella is obtained as the 'fines' are retained on the top of the bed which itself acts as a filtering medium.

This type of extractor has certain obvious advantages. Firstly, the rate of circulation of miscella could be varied at will at each extraction stage independent of the other stages. In other words, maximum rate of circulation permitted by the percolation through the bed can be maintained at every stage. Secondly, the total through-put of solvent through the extractor is independent of the rate of circulation of miscella in different stages. Thirdly, channelling effect is minimised by fixed rakes or ploughs which prevent the 'fines' settling on top os the bed from interfering with percolation. Fourthly, the moving band is kept clean by mechanical brushing and reverse rinsing provisions in the extractor. Fifthly, the facility of regulating at will the height of the bed and the speed of the moving band makes it possible to achieve flexibility in operation.

While De Smet Extractor is undoubtedly a distinct improvement over the earlier extractors, it is not without its own disadvantages. In practical operation 'fines' do get into the miscella through interstices between the rectangular elements of the band conveyor. The time required for extraction is relatively high - 2 to 3 hours. The extractor is bulky and occupies a lot of space for a given tonnage - a serious disadvantage for larger capacities. In fact, a single extractor can handle only about 250 Tonnes of soybean/24 hours and for higher capacities multiple units are necessary while other types of extractors can handle 1500/2000 Tonnes per piece.

Lurgi of West Germany have also switched over to a horizontal type extractor in recent years. But, they have two moving bands and a set of rectangular boxes, topless and bottomless, moving over the bands for compartmentalisation. The movement of all the bands is synchronised with a special mechanism. The advantage claimed is turn-over of the bed half way through extraction when it falls from the top to the lower band.

French Oil Mills of U.S.A., who offer a range of extractors, have a horizontal model too, which is said to have been very popular though current trend for larger capacities appear to have shifted preference to their stationary basket type extractor.

Cylindrical Extractor - Blaw Knox & French.

The Rotocell Extractor operates in principle as a De Smet Extractor excepting that the extraction stages are arranged in a circle and not linearly. It is a percolation type extractor with a slow moving cylindrical basket housed in a gas tight casing. The rotating cylinder is divided into a number of segments each of which forms an independent compartment. All the segments have perforated bottoms. The material to be fed to the extractor is received at one point and the extracted material is discharged at another. The perforated bottoms are hinged in such a way that they open out at the pre-determined outlet to discharge the material.

The containerised compartments of the Rotocell makes it possible to have submerged extraction, if required, without mixing up of miscelles.

A remarkable feature of the Rotocell Extractor is that the time of extraction is reduced to about an hour which is less than half of the De Smet Extractor. This is achieved by the introduction of a pre-soaking stage before the material enters the extractor. The Southern Regional Research Laboratory, New Orleans, U.S.A. had established in 1954 the importance of soaking in solvent extraction. "The solvent processing phases of filtration and extraction consists essentially of a single cooking and soaking of the prepared material in the mass concentrated or product miscelle, which contains 20 to 40% of oil by weight. Here, substantially all of the lipids are extracted. This has been corroborated by Kulkarni, Coats and Karnovsky in their recent studies on the mechanism of solvent extraction of oil-bearing materials (Improved Extraction Efficiency by double soak filtration and extraction process - E.L.D'Aquin, A.V. Graci, Jr., H.L.E. VIX and E.A. Gastrock, JAOCS, May 1961, Page 258).

The beneficial effects of pre-soaking may be summarised as follows:-

1. It eliminates interfacial resistances.

2. The oil cells are enveloped on all sides by solvent, which enters the cells and ruptures them. Consequently cell wall barriers are broken down.

3. Closest possible contact between solvent and solids is achieved, thereby promoting faster extraction.

4. Preparation ceases to be critical and is reduced to secondary importance.

This may be considered as a distinct improvement in continuous solvent extraction techniques. The cylindrical construction of the Rotocell Extractor is obviously economical in space and lends itself admirably to large-sized units.

The disadvantages of this Extractor appear to be:

a) Absence of any provision for cleaning the perforated screens in the event of their being clogged, and

b) Possible mechanical difficulties in proper closing of the perforated bottoms after discharge.

The French Extractor of the French Oil Mill Machinery Company, Piqua, Ohio, U.S.A. is basically similar to the Rotocell Extractor, the principal difference being that the basket itself is stationary while the feeding and discharge devices are rotating. It is claimed that this arrangement reduces bearing loads and results in lower installation, operation and maintenance costs.

<u>Filtrex Extractor.</u>

The Filtrex Extractor developed by the Southern Regional Research Laboratory and manufactured under licence by Wurster & Sanger, Inc., Chicago, ushered in a new concept in continuous solvent extraction. Pre-soaking of the prepared material (the merits of which have been referred to supra) is the first basic step in this extraction process. Soaking is achieved by a slurry of the flakes in the solvent under controlled conditions. The second step is the feeding of the slurry on to a rotary drum type vacuum filter.

Miscella hold-up is considered to be the determining factor in the design of extractors. (Solution Hold-up as a factor in Oilseed Extractor Design, J.D.Keane & C.T.Smith, JAOCS, May 1950, Page 199). In the percolation type of extractors, the miscella held in the material has to flow down by gravity only. In the Filtrex

Extractor, vacuum is used as an aid for speedier withdrawal of miscella from the solids. This, coupled with thin layers of the material on the filter, has made it possible to carry the washing operation in a matter of 3 to 5 minutes.

The Southern Regional Research Laboratory have discovered, as a result of further researches, that improved extraction efficiency is obtained by double-soak techniques (Improved Extraction Efficiency by double soak filtration and extraction process'- E.L.D'Aquin, A.V.Graci Jr., H.L.E. VIX and E.A.Gastrock, JAOCS, May 1961, Page 258). Under this system, flakes are slurried as usual and given a few washes on the filter. Thereafter, the filter cake is again slurried and finally washed once again on the filter. The double-soak procedure has been found to lower residual lipids at equal solvent ratio and achieve equal residual lipids at lower solvent ratio. In addition, a processor could employ less severe and meticulous condition of preparation and still achieve equal extraction performance at equal plant capacity.

The outstanding advantages of the Filtrex system is the ability to handle all types of high oil-bearing materials without pre-pressing. The actual washing stage is reduced to the duration of a few minutes as the bulk of the oil is recovered in the slurry stage.

The disadvantages of the Filtrox System are:-

1. The critical requirement of a uniform layer of the material on the filter is necessary for satisfactory operation but very difficult to obtain in practice.

2. The transfer of slurry to the rotary filter presents problems for even distribution of the material on the filter and obtaining a uniform cake.

3. The filter has obviously to be provided with an air-tight hood which presents problems of its own.

4. In practice large quantities of air enter the system resulting in excessive loss of solvent and hazard of explosive mixtures.

5. The fine metallic cloth on the filter frequently gets clogged up by fines requiring repeated back washing.

The Filtrox System is in principle very well conceived and incorporates some of the latest refinements in solvent extraction, but practical difficulties in engineering the equipment have perhaps stood in the way of its large scale industrial use.

Crown Extractor. The Crown Extractor appears to retain the basic advantages of the Filtrex System while avoiding its shortcomings. Its design reveals an advancement over other extractors.

Basically, the extractor may be considered to be a sort of drag chain conveyor formed like a loop of a particular shape with soaking and counter current washing stages alternating.

Immediately after the flakes enter the extractor, they are subjected to the first of four extraction phases. They are flooded with dilute miscella (solution of oil and solvent) which effectively washes oil from the surfaces of the flakes and 'softens' the oil cells in the flakes.

In the first phase of extraction the solvent flows down the first leg of the loop in the same direction as the flake bed. This is called the co-current extraction phase. Then, as the flake bed travels horizontally at the bottom of the loop, solvent flows through the flake bed cross-wise to the direction of bed movement. This phase is called recycling phase of extraction. Here the flake bed acts as a filter for the oil-rich miscella, as it is drawn from the bottom of the extractor.

As the flake bed moves upward in the second upright leg of the loop, it is washed by solvent flowing downward through it. This is the counter-current phase of extraction and very dilute miscella is used to extract a higher percentage of the oil from the solid. Finally in the top of the loop, the flake bed has been turned completely over and is subjected to a second percolation phase using fresh solvent for maximum oil absorption. This fresh solvent washes any oil-bearing miscella from the solids. The solids then move over a drainage area and, in a semi-dry condition, empty out of the top of the extractor at a constant rate.

This rather unusual type of Extractor has several patent advantages:

1. The time of extraction is reduced to a mere 30 minutes - about half of a Rotocell Extractor and less than a quarter of a De Smet Extractor. This remarkable result is presumably achieved by double soaking of the material during the extraction cycle, each followed by counter current washing.

2. The height of the bed is maximum 600 mm - an advantage when compared to the relatively deeper beds in the case of other extractors - and this also appears to contribute to better and speedier extraction.

3. The material under process is, during the extraction cycle, turned around 3 times and all the parts of the bed are effectively exposed to the miscella/solvent. This is perhaps another distinctive feature contributing to better performance.

4. The solvent to flakes ratio is claimed to be 0.7 : 1 on weight basis and the concentration of miscella is 30%. This low solvent to flake ratio is a noteworthy feature contributing to economy in evaporation costs and the use of smaller sized distillation equipment for a given capacity.

5. In the counter current washing sections there are no screens or perforated bottoms at the bottom, as is usual in this type of equipment. Instead, a series of specially designed bars are placed on end in juxtaposition in such a manner that they form a grid which, the manufacturers claim, while preventing the fines from passing through is also self-cleaning.

6. Both the feed of raw material and the discharge of extracted marc are at the top of the extractor - a feature conducive to safety and reduced conveyor costs.

7. An electronic device located in the feed hopper scans and automatically adjusts the speed of the extractor to the raw material input via the PIV drive, assuring ample extraction and drainage time on the one hand and eliminating the possibility of overloading of the extractor on the other.

8. The driving mechanism of the extractor is simplified to a single sprocket PIV drive,

9. The extractor is very compact and takes minimum space. A 200 Ton Extractor is only 2 ft. wide while a 500 Ton Extractor is 5 ft. wide. Capacities of about 2000 Tons per day can be handled by one Extractor.

DESOLVENTISATION OF EXTRACTED MARC

After the solvent extraction process is completed, the material (generally known as the 'Marc') is drenched with solvent. This solvent has obviously to be separated from the material and recovered. This process is known as "Desolventisation".

Effect of Heat Treatment.

There are several methods of desolventising the extracted material. In the case of soybeans, the type of heat treatment has a marked effect on the physical, Chemical and performance characteristics of the final meal. The heat treatment affects the enzyme, colour, water absorption and nutritive value of the product. (M.W.FORMO, Proceedings of the All India Workshop Conference on Processing, Utilisation and marketing of Soybeans, October 7/9, 1969).

Differences in product properties by various heat treatment conditions:

1. Mildest: Superheated Hexane vapour desolventiser PDI= 90+%

   Flakes: White, bitter flavour, enzyme active, poor nutritional value, high water absorption.

   Uses: Bleaching white bread, yeast food in brewing, protein isolates.

2.	Intermediate:	Steam desolventizing in driers ("Schnecken") PDI = 30 to 75%
	Flakes:	Very light tan, slight bitter cereal flavor, enzymes inactive, good nutritional value, very high water absorption.
	Uses:	Bread, plywood glue.
3.	Strong:	Steam desolventizing in "desolventiser-toaster" (DT) PDI = 40 to 50%
	Flakes:	Light tan, cooked cereal flavor (trace Beaniness), moderate water absorption, enzymes inactive, excellent nutritional value.
	Uses:	Doughnuts, rolls, crackers, pet foods, soymilk.
4.	Strongest:	Pressure cooking of flakes from 1, 2 or 3. PDI = 5% to 40%.
	Flakes:	Tan to brown, toasted cereal flavor, enzymes inactive, best nutritional value, low water absorption.
	Uses:	Calf milk replacers, soymilk, pet foods.

Enzymes. Soybean contains several enzymes whose activity is undesirable for many applications. Lipoxidase is one such enzyme which has the tendency to activate oxidation by air of unsaturated fatty acids to peroxides. This enzyme is, therefore, undesirable from the point of view of stability of the product and its flavour. The trypsin inhibitor interfere with digestion of protein under the influence of trypsin in the gastro-intestinal tract. Therefore, the presence of trypsin inhibitor is not desirable as it impairs the nutritional value of the material. Urease is another enzyme present in soybeans. Its propensity is to catalyse hydrolysis of urea to form carbondioxide and ammonia. The latter could be injurious to the animal when present in its food. Proper heat treatment destroys these enzymes and increases the nutritional value of the product.

For some applications, water solubility of the protein is an important consideration. This is measured by the PDI or Protein Dispersability Index which is the percentage of original protein extracted with water under arbitrary extraction conditions. The higher the PDI the better is water dispersability of the protein. Low temperature desolventisation yields a high PDI but, on the other hand, enzyme activity is also pronounced. High temperature desolventisation while destroying the enzymes also greatly reduces the PDI.

Low Temperature Desolventisation. In batch type solvent extraction plants, the desolventisation of the marc is effected in the extractor itself.

On completion of the extraction process, the solvent is allowed to drain out as much as possible and thereafter a vacuum is pulled over the vessel. Owing to the lowering of the boiling point of solvent at reduced pressure, vaporisation of the solvent takes place. In smaller vessels the desolventisation may be fairly good but in the larger vessels this may not be so. In this system of desolventisation the latent heat of vaporisation of the solvent has to be obtained from the total heat of the mass. In large extractors, the heat available may be inadequate for the purpose. Attempts are made to heat the material by peripheral jacket heating but this is generally ineffective owing to the large dimensions of the vessel and the poor heat transfer static conditions. During the extraction process, the solvent acts as a medium of heat transfer from the jacket to the material but during the desolventisation, however, such a medium is absent and hence heat transfer is poor.

Attempts have been made to get over this difficulty by the use of open steam but extensive condensation of the steam results in lump formation which makes the release of vapour more difficult, not to speak of unloading difficulties. By and large, desolventisation under these conditions is unsatisfactory.

<u>Vapour Phase Desolventisation.</u> In 1952, BELTER et al studied the desolventisation of Hexane laden mare of soybean flakes at low temperature by a flash desolventisation procedure. It was observed that there was no denaturation of protein which was generally observed in the commercial desolventisation operations. Subsequently the process variables were studied by BREKKE et al in 1959. The Flash Desolventiser Process employs superheated Hexane vapours in direct contact with solvent wet feedstock to provide the heat required for vaporisation of solvent and to convey solids through the desolventising tube to a cyclone separator. A major portion of these vapours are re-heated and re-cycled in the process. In the flash desolventiser process, direct contact is obtained between solids and super-heated vapours. Extensive surface area of the flakes is fully used for heat transfer. The solids are simultaneously dried and carried to the cyclone separator. The temperature differential progressively decreases. The high heat transfer rate combined with the thin flakes permits rapid solvent removal by subjecting the solids to

elevated temperature for only a few seconds. The flakes are cooled immediately. The instantaneous heating at high temperature and subsequent cooling protects the heat sensitive proteins. In the flash desolventising system, a high degree of solvent removal is obtained even though the solvent is vaporised into an atmosphere of its own vapour.

The material is fed through an airlock valve into the solids inlet of the flash desolventiser. At the point of entrance, a stream of superheated hexane vapours meets the flakes which practically fluidise the mare and carries it into the desolventising tube. The vapours as well as the desolventised soybean flakes are carried into a cyclone separator. The hot vapours are fed back to the blower for further recirculation. The desolventised flakes are discharged from the bottom of the cyclone through an airlock valve into another cooling duct where cooled air is blown to cool the meal. The fluidised cooled meal is then precipitated in a second flake collector. The entire installation, except the cooling duct, is completely insulated to prevent heat loss.

Drawbacks. This process, however, calls for a careful evaluation of the following factors:

1. The lipoxidase enzyme which promotes activation of the oxidation by air of unsaturated fatty acids to peroxides is not eliminated. It is called enzyme active soyflour. This enzyme helps in bread baking. It causes bleaching of the yellow pigments of the wheat flour. The flour will, however, carry a strong characteristic "beany" flavour.

2. The trypsin inhibitor is not completely destroyed.

3. The urease activity is not reduced.

However, the high protein dispersability index, if desired, would be one of the major advantages of this process.

Medium Temperature Desolventisation with Schneekens. In the earlier continuous solvent extraction plants and in some discontinuous plants too, desolventisation of the marc is effected by passage of the material through a series of horizontal steam jacketted cylinders in which the material is progressed by rotating paddles. The material passes in thin streams and heat transfer under these dynamic conditions is fairly good. The solvent vapours, which are released, are aspirated out of the unit into the condensing system. The temperature of the material emerging from the desolventising unit is generally 95 to 100°C. Soybean flakes desolventised under these conditions yield a product with a PDI range of 60 to 80. Such a product has a high water absorption quality with a mild flavour. Nutritional characteristics are, however, not found encouraging. As most of the continuous solvent extraction plants in the country have only Schnecken type driers, they would have to add a toasting unit if they wish to process soybeans.

DESOLVENTISER TOASTER

High Temperature Treatment.

The Desolventiser Toaster process, which made its appearance on a commercial scale in 1950 in U.S., has totally eclipsed the comparatively pedestrial type of tubular driers. One of the special reasons would be that both the major oilseeds in the U.S., Soybean and Cottonseed, do require high temperature treatment for various reasons.

One of the principal advantages of the DT process is that soybean meal produced has uniformly excellent nutritional characteristics. (Reference D.T.Process for Soybean Meal by Sipos & Witte, JAOCS, March 1961, Page 11).

Optimum conditions of toasting desolventised flakes.

It may be recognised that the optimum time and temperature for toasting are inter-related and may vary for different species of animals. Evans and McGinnis demonstrated that soybean flakes heated to 100°C in autoclave for 30 minutes are superior to flakes receiving greater amount of heating. An increase in the time of heating and temperature showed lower nutritional value for the flakes. Hayward and later Altschul et al indicated that the moisture content of the flakes will have to be properly controlled to yield a nutritionally superior toasted meal. The presence of moisture increases the rate of destruction of urease enzyme and the anti-trypsin factor. It also results in a rapid change of reduction in protein solubility in water.

Operation of DT.

The basic DT design consists of a series of cylindrical kettles arranged vertically in such a manner that the meal can flow by gravity successively from the top kettle to the bottom kettle. The meal-flow through different stages may be controlled by automatic gates. The solvent wet mare from the extractor enters the DT through the top kettle. Open steam is injected into the solvent laden material through hollow shaft. The shaft has mixing sweeps also fitted with steam injection nozzles. The injection steam is at a higher temperature and tends to condense on the flakes. Consequently, necessary heat is furnished by the open injection steam to vapourise the solvent. Sufficient live steam is injected in the top most kettle to vapourise all of the solvent and heat the flakes to approximately 200°F. As the meal flows into the lower kettles, the temperature of the meal is further increased by introducing steam into the jackets of the double bottom plates and also into the jackets around the shell of the DT. During this passage, part of the moisture is also removed and the desired moisture level could be maintained by proper steam control into the jackets. Finally, the desolventised toasted meal flows out of the final gate into a screw conveyor or a specially designed plug conveyor.

Expanded Dome. In the modern DTs, the upper desolventising portion of the equipment is made into an expanded dome. This lowers the velocity of the vapours leaving the surface of the meal preventing fluidisation of the bed. Consequently, it would also augment the capacity throughput. It may also be construed that the entire DT is divided into the desolventising zone and the toasting zone by addition of this expanded dome. As the live steam required for the desolventiser function has to flow through a deeper bed of meal before leaving the DT, it would consequently reduce the quantity of live steam required. It improves the contact between the live steam and the meal.

Modern Practice.

Unlike the earlier DTs, the live steam is injected in the third compartment and the hot steam and hexane vapours will have to pass through the second and first stages in that order. The designs of the first and the second stages are also made in such a manner as to provide a judicious contact passage. The design of this passage would on the one hand make it possible for the hot steam vapours to come into intimate contact with the entering meal and on the other hand avoid unnecessary development of undesirable pressures in the DT.

It may be of interest that about 90% of heat input for the entire desolventising and toasting operations comes from the injected live steam into the third chamber. In fact, this is exactly the basic function of the DT by which necessary moisture level is reached by condensation of the steam. The subsequent toasting at high moisture content required to optimise meal quality is a corollary of the first desolventising operation where the condensed steam provides the necessary moisture. Detailed trials on nutritional quality of the DT process material have indicated that the time in the toasting is not at all critical. It could be varied through wide limits without seriously affecting the meal quality. The moisture content is also easily controlled as this is primarily related to the solvent content of the extracted soybean flakes at the inlet of the DT. There are, however, two factors which seem to be responsible for the excellent quality of protein:

1. The manner of injecting moisture uniformly to individual flake particles, and

2. The cellular explosion due to vaporisation of solvent.

In the DT, the steam environment characterises the desolventising section of the unit. Necessary heat in this zone is furnished by live steam condensing upon the individual particles. This is in contrast to the earlier methods of toasting where water as a liquid was mixed with the dry flakes for the subsequent toasting operation. This always resulted in improper distribution of water uniformly to all the flakes and resulted in a meal of ambiguous nutritious quality. In the combined DT operation, each flake particle responds uniformly to treatment in the subsequent toasting sections preventing overtoasting of some and undertoasting of others, in view of the fact that the injected live steam condenses uniformly on all the flakes in the desolventising operation. The result has been minimising the loss of valuable nutritional factors.

Destruction of cell walls.

Histological studies of the DT soybean meals have shown an unusual destruction of the cellulosic cell walls and agglomeration and coalescence of the protein grades present. It is obvious that the total destruction of cell wall is due to explosive vaporisation of solvent in the desolventising zone by the injected steam. In detailed tests done by Central Soya at their laboratories, it was observed that the DT meal presented an excellent microscopic cross section showing total destruction of the cell walls. Correlative feeding tests of the meal showing such a microscopic cross sectional views have produced excellent results in contrast to the poorly toasted meal or a combination desolventising, water addition and toasted meal where the total cell destruction was not noticed.

<u>Time of Toasting.</u> From various experimental planned tests it was observed that the optimum nutritional value is maintained at 10 minutes of toasting and beyond that, even after toasting to 40 minutes, the reduction to either the gain or protein efficiency is nominal. Striking a mean it is observed that a toasting time of 20 to 30 minutes is rather significant. Since the trade is also interested, for some unknown reasons, that the meal is brown, the toasting time should be governed by this consumer acceptance standard. Results of the various operations have shown that the urease activity and the presence of the trypsin inhibitor changed considerably by the time the meal reached the third chamber of the DT. Unfortunately in the process the water soluble protein, thiamine, is also destroyed. A mean between

the trypsin inhibitor reduction in the urease activity and the retention of thiamine should be aimed at the toasting process. During the period of this work, some investigation was also done on the pot extracted meal samples. Notwithstanding the fact that open steam is injected also in the pot extracted meal, the histological heating and feeding results for these meals were found to be quite inferior. The reasons for this low meal quality could be that the rate at which steam is admitted to the pot extractors is low and the process is not a continuous one resulting in the meal near the live steam inlet at the bottom of the pot being subjected to different toasting conditions from those of the meal at the upper part of the bed.

The other attractive features of the DT process are lower solvent loss, minimum amount of desolventising equipment, less building space, safer plant operation and substantial reduction of overall steam usage by utilising the heat content of DT vapours for miscella evaporation.

REFERENCES

1. Evans, R.J., and McGinnis, J., J.Nutrition, 31, 449-461 (1946).

2. Hayward, J.W., in "Soybeans and Soybean Products (K.S.Markley, Ed.) Vol.2, Page 891, Interscience Publishers Inc., New York, 1950.

3. Cravens, W.W., and Sipos, E.F., Altschul, A.M. "Processed Plant Protein Foodstuffs", Pages 353-397, Academic Press, New York, 1958.

4. Caskey, C.D. Jr., and Knapp, F.C., Ind. Eng. Chem., Anal.Ed. 16,640-641 (1944).

5. Modification of Method by the Soy Flour Association, Revision of, December 19, 1943.

6. Methods of Vitamin Assay, 2nd Ed., pages 107-127, Interscience Publishers Inc., New York,1951.

7. Northern Regional Research Laboratory, U.S. Dept. of Agriculture, Peoria, Ill.

8. The Desolventizer-Toaster Process and certain equipment features are covered by U.S. Patents No.2,260,254, 2,585,793, 2,710,258, and 2,776,894 and German Publications (Auslegeschrift) 1,011,270, 1,014,422, and 1,067,290 as well as several pending applications assigned to the Central Soya Company.

FINISHING SECTION.

The desolventised defatted soymeal is received in the finishing section over vibrating screens. Commercial quality 44% meal is set to pass through 11-14 mesh. The material passing through the screen is diverted for bagging. The coarse material passing over the screen is received in a Grinder and the discharge of the grinder is diverted back to the screen. By this arrangement, meal of the required grind is obtained.

If soy grits are desired, the grinder could be set to the particle size required and the discharge received on a separate set of screens. The material passing over the screen will be the grits.

Sometimes fine flour of 100, 200 or even 300 mesh may be required. The basic process remains the same. Only for fine flours micropulverisers would replace conventional grinders.

There may be occasions when some fat has to be added back to the defatted soymeal intended as cattle feed.

Lecithin recovered during the degumming of the crude soybean oil could also be added back to the defatted soymeal. For making such products, usually provision is made for adding the fat or the lecithin into the soymeal just before it is bagged. A mixing conveyor is provided in such cases for dispersing the added material in the meal.

MISCELLA EVAPORATION.

Distillation is the separation of the components of a liquid mixture by partial vaporisation of the mixture and separate recovery of vapour and residue. The vapour is usually recovered by condensation.

In an ideal case, Rault's Law is applicable to the liquid phase. The law states that the partial pressure P_1 of any component in the vapour is equal to its mole fraction in the liquid X_1 times the vapour pressure P_1 of the pure component at the same temperature. In the primary mixtures the pressure of one composition will fix the temperature and vapour composition. In other words, pressure and temperature fix both compositions. (Perry).

Systems comprising of oil and hexane have exhibited considerable negative deviations from ideal conditions. It has been found that the vapour pressure of the solvent is lower than what is calculated from its mole concentration in the miscella and the vapour pressure of the pure solvent, applying Rault's Law.

It was observed that below a solvent concentration of about 10% by weight, the boiling point becomes so high that steam stripping is essential in the final stages of solvent recovery. (Bailey).

Considerable data has been published regarding the vapour pressure curves for pure hexane, commercial hexane and miscella. The plotted curves are on the basis of log vapour pressure versus reciprocal of the absolute temperature. These have generally given straight line slope. It has been observed that below 200°F the actual vapour pressure curve of the miscella is a straight line with a slope equal to that of the vapour pressure curve of the pure solvent. The activity coefficient or the ratio of actual vapour pressure to ideal vapour pressure over the straight line portion was found to be about 0.60 for a temperature reciprocal value of 13.

Activity coefficient has a relationship with temperature. When heat is evolved upon mixing of two liquids, the partial heat of solution of components is negative and the activity coefficient rises with temperature. However, most mixture of organic liquids take up heat when mixing occurs. Consequently, the partial heat of a solution is negative and the activity coefficient value decreases with increasing temperature.

It may be stated here that the vapour pressures of vegetable oils are extremely low having regard to the fact that the boiling point of most of the fatty acids are over 350°C. The boiling point of hexane on the other hand is in the range of 62 to 69°C. Consequently its vapour pressure is high at an equal temperature. The vapour pressure of soybean oil at 308°C is hardly 0.050 mm whereas the vapour pressure of a solvent like Normal Hexane is 750 mm at a temperature of 68°C.

Apart from these, normal hexane is an aliphatic hydrocarbon and has sharp and narrow distillation range. It is, therefore, easier to separate this solvent from a mixture of solvent and tri-glyceride termed 'Miscella'. A simple evaporative distillation at a low temperature under vacuum is sufficient for clear separation of the two phases of the miscella without any difficulty. The problem, as mentioned earlier, becomes a little more complicated when the concentration of the solvent goes below 10%. It appears as though there is some amount of affinity between the tri-glyceride and the hexane based more on the dipolar moment or dielectric constants. It is possible that the residual moment of the tri-glyceride has a definite function in this also at lower concentrations. In fact, this rather strange phenomenon is also utilised in the subsequent process of recovery of traces of solvent vapours mixed with air by adsorbing it with a similar tri-glyceride.

In the process of distillation of the miscella, one of the major considerations is the effect of temperature on the quality of the edible oil recovered. More so, when the edible oil is highly unsaturated such as soybean oil which has an iodine value of 136. The protection of the oil from the deleterious effects of temperature is vitally important. Obviously, the major protection should be from the presence of air and oxygen which are likely to damage the oil and also form explosive mixtures with the solvent. Apart from these, the unsaturated fatty components of the oil tend to polymerise at higher temperature

It is, therefore, a common practice to separate the two phases at higher vacuum and maintain the temperature of the miscella as low as possible until concentration of the hexane in the oil falls below 10%. At this stage, however, as indicated earlier, drastic steps are necessary to remove bound solvent from the oil. Between the two methods of stripping at high temperature under vacuum and stripping on moderate temperature under vacuum by a stripping stream, the latter method is safer and generally used. In other words, steam distillation is utilised to strip remnants of the solvent from hexane. Steam distillation is adopted as a method in which the partial vapour pressure of steam would enable the volatile components to distil at lower temperatures due to lower partial vapour pressure. The presence of steam also helps in blanketing the high temperature of oil in low concentrate miscella from being exposed to oxygen and air.

Industrial Practice.

The miscella delivered from the extraction section will have a concentration of 15 to 30% of oil, depending on the type of extractor used. The evaporation of miscella to recover the oil is generally conducted in 3 or 4 stages.

The first stage of evaporation of the miscella is in an apparatus where the heat of the DT vapours is used for preliminary concentration. This heat exchange arrangement usually results in the concentration of the miscella to about 50 to 60%. In order to obtain best results, a vacuum of about 40 to 45 cms. mercury is maintained over the heat exchange unit.

Thereafter, the miscella is passed through a primary evaporator, usually of the rising film type, with an attached flasher for withdrawal of the flashed solvent vapours. This section generally also operates under a vacuum of about 45 cms. mercury.

In the second stage evaporator, the process of concentration is continued and the vacuum at this stage is generally higher - about 60 cms. mercury. The product emerging from this section generally has a concentration of 90 to 99%.

The last stage of removal of solvent vapours from the oil is the finishing column, where the oil is stripped with live steam under high vacuum - of the order of 70 cms. mercury. The oil emerging from the stripper is commercially free of solvent and is cooled and delivered to storage.

RECOVERY OF SOLVENT.

Large volumes of solvent vapours are to be handled in the solvent extraction plant. When the extracted marc is desolventised, all the solvent contained therein is vapourised. When the miscella is evaporated, the solvent is recovered as vapours. All the solvent vapours from the various sections are condensed in water cooled surface condensors. Considerable quantity of uncondensed gases will still remain to be handled.

Salvaging solvent from the uncondensed gases is an important factor influencing the economics of operation as well as the safety of the installation. The earlier step for recovery of solvent was the use of refrigerated water or brine for further cooling of the vent gases and condensation. of solvent. Assuming the vent gases being saturated with solvent, the quantity of solvent in the gases depends on the temperature. At 30°C, every cubic meter of gas leaving the system would carry away about one kilogram of hexane. At minus 10°C, the quantity of solvent lost could be reduced to about 130 grams per cubic meter.

Refrigeration compressors are sensitive to cooling water temperature owing to limitation of delivery pressure. In the hot weather (atleast 6 months in this country) cooling water temperature soars and compressor efficiency is at the lowest ebb. On the other hand, high water temperatures make water-cooled condensors less effective and maximum support is essential from the recovery system which it is unable to obtain. This is the major shortcoming in the refrigeration system in tropical countries.

In recent years the refrigeration system for recovery of solvent has been replaced by Adsorption System. In this system vent gases are brought into intimate contact with mineral or vegetable oil, which absorbs the solvent and ensures maximum recovery of the same under certain conditions The solvent-laden oil is stripped of solvent in a separate small evaporator, cooled and returned to the absorber. The oil is recycled in the system in the same way as the refrigerant is recycled in the refrigeration unit. The adsorption system is relatively more efficient even at higher temperatures. The equipment used is simple and does not pose any maintenance problems. Its power consumption is also very much lower than the refrigeration system.

Theory of Adsorption.

It is a common observation that separate phases brought into contact tend to approach a state of equilibrium. When pure water is placed in contact with dry air, water evaporates and the air becomes saturated. Air is absorbed by water and the liquid is saturated with oxygen and nitrogen. It is apparent that there is a sharp concentration across the interphase between two phases in contact and in equilibrium. In the region immediately adjacent to the interphase boundary, it is found that the concentration gradient is surprisingly steep as compared with the corresponding gradient at points further removed from the interphase. It may be concluded that the principal resistance to interphase transfer is to be found in a thin 'film' of relatively stagnant fluid next to the interface between phases. The thickness of such a fictitious film is termed "effective film thickness". The equation propounded by Prandtl applying the basic Reynolds assumption to the 'core' or the layer of the moving fluid is quite well known. Colburn treated the problem of the interphase material transfer through a gas in turbulent motion and obtained applicable equations. Chilton and Colburn modification of the Reynolds analogy is quite well known in the correlation between friction and diffusion of gases.

Adsorption is an extension of the above principles. When the concentration in the interfacial layers between two phases is greater than the bulk of either phase, the substance is said to be adsorbed at the interphase. Many solid substances have the power to adsorb moisture. For instance, glass and porcelain possess this property. Some porous substances have the power to adsorb gases. Adsorption is a surface phenomenon. It can increase in importance as the particles are made smaller. It also will mean that a large surface should be presented by any given substance. It is obvious that the greater the surface area presented, the better the adsorption.

Adsorption differs from absorption in being confined largely to the surface of the adsorbant. It is observed only at the surface of the solution. Gibbs has shown theoretically that those substances which lower the surface tension of a solvent in which they are dissolved become concentrated in the surface layer, whilst the concentration of substance which raise the surface tension is less in the surface layer than in the bulk of the solution.

When inorganic salts are dissolved in water, they increase the surface tension slightly. Therefore, the concentration of the salt in the top layer of the solution will be less than the bulk of the liquid. Gibbs derivedthe following mathematical expression governing the variation in concentration:

$$-S = \frac{C}{RT} \times \frac{dr}{dC}$$

Where S = excess of solute in the surface layer (the sign indicates whether there is actually an excess or a deficit)

C = concentration of solute if equally distributed

R = gas constant

T = absolute temperature and

r = surface tension

$\frac{dr}{dC}$ = variation of surface tension with concentration.

It is also the slope of the curve at the point at which the conditions are those of the experiment. Modifying this equation as below:

$$-S = \frac{p}{RT} \times \frac{dr}{dp}$$

Where p = partial pressure of the gas, a relationship was established between the adsorption of the gas and a solvent.

It may be observed that low temperatures will favour better adsorption. No chemical change will take place at this time. The greater the surface area, the better the rate of adsorption.

The adsorption isotherm is indicated hereunder:

$$\frac{x}{m} = ap^{1}/n$$

where, x = mass of gas adsorbed

m = mass of the adsorbant

and p = pressure of the gas

a & n are constant.

This conclusion gets modified in the case of adsorption from a solution as below:

$$\frac{x}{m} = ac^{1}/n$$

Where c is the equilibrium concentration of adsorbed substance in the solution. This conclusion may be re-written as below:

$$\log x - \log m = 1/n \log c + \log a$$

It may be observed that if log x is plotted against log c, a straight line will be obtained. It may also be noted that there is certain formal similarity between the adsorption isotherm and the distribution law.

The above concepts are utilised in the adsorption of vapours of hexane mixed with air by an adsorbent. Oddly enough the adsorbant in this case is the tri-glyceride oil itself. As explained earlier, the dielectric constant lie in the range of 3.0 to 3.2 for normal oils. It has been proposed that besides the phenomenon of diffusion the hexane vapour through the interphase of the oil and concentration of it on the surface layer of the oil, the dipole moment imparts some amount of co-ordinate covalent linkage between the tri-glyceride molecule and the hexane molecule. It is obvious that the following conditions will have to be met with in the phenomenon of adsorption and the hexane vapour from the hexane-air mixture by the adsorbant oil:

1. The temperature of the oil must be reasonably low.

2. The temperature of the mixture of gases should preferably be ambient.

3. It is advisable to have no moisture present during this process.

4. The surface area to the volume ratio should be deemed to be infinite. In other words, the greater the surface area, the better the rate of adsorption.

Safety in Solvent Extraction Plants.

Safety is of utmost importance in any industrial establishment where lives of several human beings and property worth millions are involved. Safety is doubly important in a process when dangerious petroleum is used as solvent. That the accent on safety is not exaggerated is evidenced by the fact that more than half a dozen major fire disasters have occurred in solvent extraction plants in the country in the last decade, the minor ones being too numerous to keep track of.

This does not mean that there is any inherent danger in a solvent extraction plant; it only means that the neces-sary safety features should be in-built in the plant, which would render it free from danger in operation.

Primarily all the equipment in which solvent is involved should be vapour-tight, leaving no possibility of escape of solvent from the system. Particular care should be taken in the case of moving shafts which operate in equipment handling solvent. It is customary to use well-designed mechanical seals to eliminate possibility of leakage of solvent. The valves in the solvent and miscella circuits should be of good quality - such as all-cast iron lubricated plug valves of the 'AUDCO' Make. The pipes should be of the heavy gauge quality IS-1239. The joints, if any, in the piping should only be of the flanged type with flanges conforming to BSS Table D or better. No threaded joints should be permitted in the solvent and miscella circuits.

The plant should be so designed that there should be no possibility of a pressure developing in the solvent circuits. It is particularly important that there should be no valves or obstruction in the solvent vapour circuits so that hazards due to mal-operation or mistakes are eliminated.

Liberal provision of sight glasses on the equipment is necessary in order to enable the operator to observe what is going on inside the equipment.

Flow Indicators in the piping is similarly necessary in order to keep an eye on the flow in the piping. Needless to say, sight glasses and flow indicators should be vapour-tight.

The products leaving the plant should be free of solvent. The oil should be thoroughly stripped under highest possible vacuum with a view to rendering it solvent free. The meal should likewise be perfectly desolventised before it leaves the system. Solvent-laden meal is a very big hazard not only in the factory itself but all down the line where the meal is handled and transported.

All the effluent leaving the system should be thoroughly stripped of solvent in a flasher before it is admitted into the sewer. Vent gases leaving the system should be thoroughly rid of solvent vapours by means of modern recovery equipment.

The entire electrical system in the solvent extraction plant must be of genuine explosion proof quality of the approved standard. Where the control panel is not explosion proof, it should be housed in a separate enclosure pressurised with a fan which should draw the air from a height of at least 2 metres above the highest point of the solvent extraction plant. The access to this enclosure should be of the double door type with door closers fixed on the doors. For visibility from the plant, a glass window is usually provided; this should also be of the double glass type with a gap in between the glasses.

An electric control panel for supervising the operations of the plant is a MUST. The panel should have sequencing and interlocking devices to prevent the possibility of mal-operation as far as possible. When the steam pressure should fall below a pre-determined minimum, an alarm should be raised to draw the attention of the operator. The pressure of steam has a direct influence on the desolventization of the marc and maintenance of vacuum/under-pressure in the plant.

In a like manner, if the cooling water temperature should rise above a pre-determined maximum, an alarm should be raised in the plant. If any of the electric motors should stop for any reason, the alarm system should be actuated. The alarm system should be audible as well as visual for maximum effectiveness.

As power failures are rather common in this country, some built-in measures are necessary for maintaining safety standards. The immediate effect of power failure is cessation of water supply as water circulating pumps are electrically operated. But cessation of power may not affect the steam supply except where packaged boilers are used. Therefore, a hazardous situation can be created in the plant as, on the one hand, continuation of steam supply would vapourise solvent and, on the other, as water supply has ceased, there will be no means of condensing the solvent vapours. In such a situation, pressure is likely to develop in the entire system leading to blow-out of vapours. To prevent such an eventuality, two measures are necessary:

1. An emergency water storage tank of adequate capacity should be installed at proper elevation with automatic gadgets which will, in the event of power failure, cut-in the water supply from the emergency tank into the water system of the plant. When normal conditions are restored, the emergency tank would fill itself up and be ready for any eventuality.

2. The steam supply to the plant should be cut off when there is power failure. This can easily be accomplished by means of a magnetic or motorised valve on the main steam line serving the solvent extraction plant.

The extraction plant should be so located in the factory that a clear space of 50 ft. is provided all around the plant. No compromise should be tolerated in this regard.

Further a solid, unbroken retaining wall should be constructed all around the extraction plant at a distance of 30 ft. from the periphery of the plant. The area inside this retaining wall is the "Prohibited Area". The area between the 30 ft. and 50 ft. distance from the solvent extraction plant is the "Controlled Area".

Any activity where naked flame or fire is involved - such as boilers - should be located atleast 100 ft. away from the solvent extraction plant with the firing end farthest away from the plant.

Only sparkless tools should be used in the extraction plant.

High importance should be attached to the proper maintenance of equipment in the extraction plant and essential spares should always be readily available.

The operators in the solvent extraction plant should be intelligent and alert, understand the process and be thoroughly briefed and trained in proper operation of the plant. In particular, they should know what is to be done in the event of an emergency.

A liberal supply of fire extinguishers of the 'Foam' type should be provided at strategic places in the plant.

It is also desirable to have a "deluge system" to be used in times of emergency.

As certain materials processed in the solvent extraction plant have a tendency towards spontaneous combustion, automatic sprinkler system in the warehouses where they are stored would be desirable.

PLANT AND MACHINERY.

One of the outstanding features of the age we live in is the remarkable progress in Science and Technology. The horizon of human knowledge is expanding so fast that what was impossible yesterday is feasible today and what was modern and up-to-date earlier becomes obsolete overnight. Especially in the processing industry, technological advancement has a profound impact. It is futilo to expect to do good business in the present-day competitive world with out-of-date equipment or grandfather's techniques. Therefore, while contemplating a new activity like the processing of soybeans, an indispensable pre-requisite is to survey the latest technology, machinery and methods available and select the best for this new venture.

The situation is not quite so simple. Latest know-how or modern machinery may, in some cases, have to be imported, as it is not available at present indigenously. In company of the developing countries of the world, India has an adverse balance of trade and limited foreign exchange resources which have to be utilized judiciously for Defence, Food and many other essential requirements. It is, therefore, natural that every possible effort be made for manufacturing as much of the equipment in the country as is possible and reducing imports to the barest minimum. In this matter there could hardly be any difference of opinion.

We have, therefore, a situation where two basic and important considerations have to be reconciled. While on the one hand the scarce foreign exchange resources of the country have to be spent with care and circumspection to yield best results, on the other a new industry should not be condemned to congenital handicaps, which will sap its competitive strength. The soybean processing industry is no mere commercial venture; both the products which are produced - oil and protein - are articles of food. Not only are higher standards of quality essential in food products, but the price of the products should also be reduced to the minimum in order to bring essential food products within the reach of the common man. Further, the soybean processing industry has a big potential in earning foreign exchange as edible protein products as well as commercial quality soymeal have a wide market outside the country. In order to be able to penetrate this market and capture a substantial share of the business, the soybean processing industry should have inherent competitive strength.

An objective view of the facilities available in the country tends to the conclusion that out of the six basic sections of the soybean processing plant (vide page 24), the requirements of four - Evaporation of miscella, Recovery of solvent, Finishing of Meal and Desolventisation of marc -. can be made from indigenous sources in keeping with international standards. It is only in the other two sections - Preparation and Extraction - that overseas assistance appears necessary for the present.

Proper cleaning of soybeans is a very important first step in the processing activity. The importance of proper cleaning is generally not fully realised. As substantial part of the extracted meal would undoubtedly be used for edible purposes, either in the form of edible flour or as a raw material for other sophisticated food products, top class cleaning equipment is obviously a MUST. The 4-Stage Cleaning Equipment, referred to elsewhere in this report, should be imported.

The Crackers and Flakers are important pieces of equipment in the Preparatory Section. Chilled cast iron rolls, used in these machines, of proper quality - approximately 550 brinnel hardness - do not appear to be readily available in the country. Further, the current practice is to have hydraulic drives for the Flakers in order to ensure finger tip control of the quality of preparation. This aspect is critical, as their performance has a vital bearing on the subsequent processing operations (vide page 31). Such hydraulic drive equipment is not available in the country. Therefore, it is imperative that atleast the Flakers be imported for the time being.

With regard to the Extractor, for smaller sized plants - 100 Tonnes/24 hours of beans - indigenous extractors may be adequate. It will be observed elsewhere in this report that the optimum size of the soybean processing plant has been discussed and a 250 Ton/24 hours plant with facility for expansion to 500 Tons appears to be best suited for the industry. The extractor is the heart of the entire operations and is the most expensive item in the plant. It will be most advantageous to have even at the start an extractor which can potentially handle

500 Tons of beans in 24 hours so that subsequent stepping up of the capacity to this figure could be achieved with ease and facility as and when required. No one in the country appears to be in a position at the moment to manufacture a single extractor to handle 500 Tons of beans a day. Therefore, import of the extractor becomes necessary.

Other sundry items which need to be imported are: Continuous Weigher for determining the quantity of beans issued to the processing plant from bulk storage and continuous bagging and sewing equipment in the Finishing section.

Sources of Machinery.

In the United States the following firms are well-known in the soybean processing industry:

1. The V.D.Anderson Company,
   1935 West 96th Street,
   Cleveland, Ohio 44102, U.S.A.

2. M/s. Blaw-Knox Chemical Plants, Inc.,
   One Oliver Plaza,
   Pittsburg, Pennsylvania 15222, U.S.A.

3. The French Oil Machinery Company,
   Piqua, Ohio 45356, U.S.A.

4. M/s. Crown Iron Works Company,
   1229 Tyler Street N.E.,
   Minneapolis, Minn.55413, U.S.A.

All of them have been contacted.

The V.D.Anderson Company, in their letter dated March 31, 1970 stated: "Your original inquiry to us regarding the solvent extraction plant has been forwarded on to the Blaw-Knox Company, Pittsburg, Pennsylvania, USA, because we are unable to manufacture a solvent plant for the capacity competitively with the Blaw-Knox Company, hence we felt it best to forward your inquiry on to them."

Messrs.Blaw-Knox Chemical Plants, Inc., in their letter of March 23, 1970 stated: "Blaw-Knox Chemical Plants,Inc. are engineering contractors with more than twenty years of experience in designing and building soybean and other vegetable oil seed processing plants. We have a considerable amount of proprietary equipment and know-how in the oilseeds processing field. However, we do not manufacture the equipment and therefore we do not have catalog prices and the other information which you requested. From your letterhead we note that you are "Design, Consulting and Construction Engineers". Therefore we are certain that you understand the large cost involved in preparing the requested information and that we could only work with you on a reimbursable cost basis.". Notwithstanding subsequent persuasions, they have not furnished any further information.

The French Oil Mill Machinery Company, USA, were pleased to supply some data and information, which are reproduced in Exhibit 'A'. They have also taken the stand that further correspondence is not justified unless formalities for import of equipment are completed.

Messrs. Crown Iron Works Company, through their export agents, Messrs. Du-Val Industrial Foreign Trade Corporation, Dallas, evinced a keen interest in the Feasibility Study. They were good enough to arrange a personal discussion in India with one of their representatives in order to explain in detail the merits of their equipment. They have also given a detailed proposal for a 250 Ton/24 hours soybean processing plant, which is reproduced in Exhibit 'B'. Messrs.Crown Iron Works Company manufacture only the solvent extraction plant proper and they do not manufacture the equipment for preparation, finishing and other sections.

For Crackers and Flakers, Messrs.Ross Machine & Mill Supply Plant, P.O. Drawer 26468, Oklahoma City, Okla 73126 are well-known in U.S.A. They have also been pleased to send a proposal for their machines to suit 100, 250 and 500 Tonnes/24 hours capacity. Their proposal is reproduced in Exhibit 'C'.

For proper and effective cleaning of soybean, the Forsbergs, Inc., Thief River Falls, Minn. U.S.A. have been extremely helpful. Their equipment is very impressive and reasonably priced, Their proposal is also reproduced in Exhibit 'D'.

As bulk storage of beans is envisaged in the project, preliminary cleaning and drying is desirable before they are stored for a long time. Forsbergs Pneumatic Scalper with a capacity of 2000 Bushels per hour appears to be best suited for the purpose. It is priced U.S. $1354/- only without fan and motor. For drying the beans, proposals from three firms have been received - Messrs.Aeroglide, 6300 Hillsboro Road, Box 1839, Raleigh, North Carolina 27602; Clipper Dryers of Messrs. A.T. Ferrell & Company, 1621, Wheeler Street, Saginaw, Michigan 48605, USA; and Messrs.Campbell Industries, Inc., 3121, Dean Avenue, Des Moines, Iowa 50317, USA. The abstract of their proposals will be found in Exhibit 'E'.

For continuous Bagging and Sewing equipment, Messrs.Howe Richardson Scale Company, 680, Van Houton Avenue,Clifton, New Jersey 07015, USA, have offered a proposal, which is displayed in Exhibit 'F'.

Indigenous manufacturers who are in a position to offer suitable equipment for the soybean processing industry are:

(a) Messrs. De Smet (India) Private Limited, Post Box No.428, BOMBAY-1.

(b) Messrs. Servotech Engineers Private Limited, Post Box 6073, Colaba, BOMBAY-5.BR.

The prices quoted by Messrs. De Smet (India) Private Limited for 100, 250 and 500 Tonnes capacities as well as their specifications for 250 Tonnes/24 hours plant will be found in Exhibit 'G'. It will be evident from their specifications that:

1. No cleaning equipment for soybeans is provided for in the Preparatory Section.

2. No provision appears to have been made for processing and disposal of hulls.

3. Only a single stand Cracker with one pair of rolls is indicated in their specification. By normal standards, this appears to be inadequate for the duty involved.

4. The same remarks apply to the single Flaker in the specification.

5. Grinding and Sizing equipment is absent in their Conditioning Section.

6. Bagging and Sewing equipment is likewise absent in their Conditioning Section.

7. Accessories and auxiliary equipment like bulk storage tanks for hexane, emergency water storage tanks, oil holding tanks, steel structures for the Preparatory & Conditioning Sections, Panels and electrical wiring materials for the Preparatory and Conditioning Sections, etc. are not included in their specifications.

Proposals from Messrs. Servotech Engineers Private Limited, Bombay, are appended in Exhibit 'H'. They have offered four alternatives:

Alternative I: The "250/500 Special" Plant is basically designed for ultimate 500 Tonnes/24 hours processing of soybeans with 600 Tonnes/24 hours 'CROWN' Extractor, open air steel building for the extraction plant designed to house 500 Tonnes/24 hours equipment, all the mechanical transport equipment in the Extraction and Preparatory & Finishing sections are designed to handle 500 Tonnes. Complete Forsberg Cleaning Equipment with Screen Aire, Destoner and Gravity Separation Units is included in the Preparatory Section. 2 Nos. Ross Hydraulic Flakers are provided. Two pairs Krakers are likewise provided. In the Finishing Section Howe Richardson Automatic Bagging and Bag Closing machines are provided. The equipment is complete with bulk storage tanks for hexane, emergency storage tanks for water, plant day tank for oil, supporting steel structures for the Preparatory & Finishing sections, control panels and electrical wiring materials in the Preparatory section. The specification of of "250/500 Special" Plant is reproduced in Exhibit 'H'.

The attractive feature of this proposal is moving up to 500 Tonnes production is accomplished with ease and facility. The Extractor needs no change as it is basically intended for high capacity. In the Desolventizing section, the Dexanizer-Toaster will remain unchanged; some auxiliary equipment will be added in order to make this section handle the enhanced capacity. Some balancing equipment will also be required in the Miscella Evaporation section for which provision is made in the layout of the plant. Likewise provision is already made in the Preparatory & Finishing sections for addition of equipment. The entire mechanical transport equipment is ad initio designed for 500 Tonnes capacity.

The overall merit of this proposal is evidenced by the fact that the total cost of the 500 Tonnes/24 hours plant, including all the top class imported equipment and despite heavy import duty etc., is still Rs. 1.5 million less than the fully indigenous 500 Tonnes plant quoted by Messrs. De Smet India Private Limited.

Alternative II: Alternative II is similar to Alternative I excepting that provision for subsequent expansion to 500 Tonnes is not made. All the imported machinery is identical in both alternatives excepting that in Alternative II, the Extractor is of 250 Tonnes/24 hours capacity.

Alternative III. In Alternative III, a basically indigenous 250 Tonnes/24 hours plant is proposed. Only critical components and items not available in India to the value of 7.5% of the value of the plant are to be imported.

Alternative IV. In Alternative IV, a 100 Tonne/24 hours indigenous plant is proposed. Only critical components and items not available in India to the value of 5% of the value of the plant are to be imported..

UTILITIES: To Process 250 Tonnes/24 hours of Soybeans

Power: The connected load for the project would be approximately 1650 H.P. made up as as follows:

Preparatory Section	..	600	H.P.
Extraction Plant	..	200	"
Finishing Section	..	300	"
Cell Storage Section including Wagon Tippler, Bean Drier, etc.	..	300	"
Water Circulating Section	..	100	"
Boiler House	..	50	"
Miscellaneous	..	100	"
Total	..	1650	H.P.

2 Nos. 750 KVA Transformers with the necessary HT and LT equipment would suit the requirements of the project.

Steam: The steam requirements for the project would be approximately 4000 Kg./hour at 10 Kg./Sq.cm. pressure in the plant allowing for margin of safety. A Boiler with an evaporation capacity of approximately 5000 Kgs./hour at 14 Kg./Sq.cm. pressure is desired. Package type fully automatic boiler would ensure best results.

Water: About 300 cu.meters of water would be required for the project.

Abrasive nature of Soybeans.

Those who have handled soybeans draw particular attention to the hardness and abrasive nature of the beans resulting in rather heavy wear and tear on many parts of the equipment. Flights of screw conveyors are reported to have become razor-sharp within a few months of operation. Chilled cast iron rolls of the preparatory equipment wear away twice as fast with soybeans as compared to other oil-bearing materials. Therefore, this special property of the beans should always be kept in mind in the choice of materials of construction. It also underlines the importance of regular inspection and preventive maintenance in the operation of the plant.

LOCATION OF PLANT.

In the selection of a proper location for an Industry, several basic considerations have to be kept in view:

Transport facilities. Large quantities of raw materials and finished products have to be moved into and out of the factory. Transportation and handling costs are quite considerable in a Processing Complex of the type in view. Proximity to a railhead, certainly Broad Gauge, and if possible Metre Gauge as well, is an essential requirement for the selection of factory site. A private siding to the factory site will be equally essential; as it is expensive, the shorter the distance from the railhead to the factory, the better it would be.

Proximity to a highway and good access roads are equally important as a substantial part of the goods are liable to be moved by road.

Availability of Power. When fully developed, the Project would have heavy requirements of power and in the selection of a site, the availability of power and the facility of drawing

High tension lines to the site should be borne in view. The cost of electrical energy is an equally important consideration as it is a major component in the working costs.

Availability of Water.

Plentiful supply of water would undoubtedly be required both for the process and for drinking and washing purposes. Before the choice of a site, the possibilities of obtaining required amount of water should be checked and ensured.

Proximity to basic raw material.

Soybean is a primary raw material for the Processing Complex. In view of the large tonnage involved, storage and handling in bulk would obviously be beneficial. Creating bulk storage facilities with necessary mechanical handling equipment at the project site is an expensive proposition and in order to derive maximum benefit, it should obviously be necessary to receive the beans at the project site in bulk.

To make this possible, the following facilities are required:

1. At the farm level, facilities should be created for storing soybeans in bulk along with the necessary mechanical handling equipment.

2. Suitable rolling stock should be available for transportation of the beans in bulk from the loading centres to the project site.

It is conventional for farmers in the country to bag their produce and weigh the bags before they are delivered to the buyer. This is an age-old procedure which they may not give up easily in favour of modern practices. It would take a good deal of persuasion for them to accept bulk weighing practices. Further, the farms in the country being small, it may not be feasible to have bulk storage and mechanical handling facilities at every farm. Therefore, suitably located centralised collection, weighing and storage facilities would have to be created as the first step for bulk transportation of the beans. Some agency, like Co-operative Marketing Societies, should exist to handle this matter on a basis acceptable to the farmers as well as to the processors.

The need for suitable rolling stock is equally important. As mechanical unloading is essential, the type of rolling stock assumes importance. Hopper Cars, as are being used now for movement of minerals and ore, appear, prima facie, suitable from the unloading point of view. The design of the car would have to be suitably modified in order to convert it into a closed and pilfer-proof car and at the same time the cubical contents should be adjusted to accommodate the optimum load. Alternatively, the standard closed goods wagon could be used for the transportation of beans in bulk provided an end Rocker type wagon tippler is installed at the unloading point. Further, an inlet should be provided at the top of the closed goods wagon for loading in bulk.

Proximity to markets for finished products.

In the first phase, soybean oil and commercial 44% meal are likely to be the finished products available for disposal. Vanaspati factories are the consumers for soybean oil. The meal is destined for export in the beginning stages. Distance to the nearest Port will be a consideration.

Proximity to source of fuel.

Coal or furnace oil will presumably be the fuel for the project. Distance through which the fuel would have to be hauled to the factory is a factor which needs consideration.

Proximity to a township.

Residential facilities for the staff and workers of the project would undoubtedly be necessary. To begin with, it may not be feasible to create a private township for their living. Therefore, proximity to an existing township would be a great advantage as it would eliminate housing problems.

Facility for disposal of effluents and wastes.

In some locations disposal of effluents may pose a problem. Though the effluents from the project do not contain abnoxious materials, nevertheless facilities for proper disposal would be necessary and this consideration should also be kept in view.

Favourable soil conditions.

In some areas the soil is poor and excessive and expensive foundation would be required. It would be prudent, therefore, to survey the soil conditions before the choice of a site.

Topical considerations.

The Processing Complex of the type envisaged is a large enterprise involving huge sums of money. The investors are entitled to pursue their business peacefully, earn a legitimate return which should be adequate for the growth and development of the business as well as for providing a fair return to the investors. A climate of peace is obviously essential. While in establishments of this type some problems with labour are to be expected and should be faced and solved squarely, there are unfortunately regions in the country where labour unrest is endemic, caused by factors unrelated to employer-employee relations. Besides, some local Governments appear unable or unwilling to afford the type of protection to which any citizen in a civilised country is entitled to. In the circumstances, a topical consideration for entrepreneurs in the country is a careful assessment of the environmental climate in the region in which the project is to be located. It would be unrealistic to underrate this consideration, temporary though, we hope, it will be.

THE PROJECT

The first phase of the Project is designed to process 250 Tonnes of Soybeans in 24 hours and produce:

1. Soybean Oil, and
2. Commercial Soymeal or Edible Flour.

Provision is made for expanding the capacity of the plant to 500 Tonnes at a later date, if required, and for the addition of other processing units either for the Oil or for the Defatted Meal.

Factory Layout Drawing No. LOT:FY:793.

The layout of a factory has to be carefully designed to suit individual requirements and locations. In order to highlight the considerations on which a factory is laid out, a typical layout is furnished in Drawing No.LOT:FY:793.

The private Railway Siding enters the factory from the left and a weighbridge is provided for determining the weight of incoming and outgoing wagons, whenever necessary. There are three parallel lines in the factory area. One line serves the beans unloading warehouse (27), Meal Storage Warehouse (6), and the Raw Oil Storage Section (7). The other line is intended to serve the Seed Warehouse (26), the Vanaspati Warehouse (19) and the General Store (16).

The centre line is for the facility of turnround of wagons in the factory. It will be noticed that the incoming and outgoing materials can be conveniently loaded into wagons in the Siding.

The factory also has a good net-work of roads, 10 metres wide. The road system is so arranged that incoming materials can reach the designated points and outgoing materials can be picked up from the designated points with ease and facility. In the case of Soybeans received by Road, the trucks can drive in straight into the Unloading Warehouse (27), discharge the load and drive out without any unnecessary movements.

Adjacent to the unloading warehouse (27) is the Silo Storage Section (1) with 10 RCC silos, each with a capacity of 2500 tons of beans. Head Works (2) house the Mechanical Transport Equipment, the Pneumatic Scalper and Bean Drier.

Across the road and opposite the Head Works is the Preparatory Section (3). The Day Bin for beans (5) is situated alongside. The Solvent Extraction Plant(4) is conveniently located 50 feet away. The Finishing Equipment is also located in the same building (3). The packed bags are to be stored in the adjoining Meal Warehouse (6).

The Boiler House (15) is nearer the proposed Vanaspati Plant as high pressure steam is required there and pressure drop should be avoided. The Boiler House is more than 100 ft. away from the Extraction Plant, with the firing end farthest from it in the interest of safety. There is ample room for storage of coal, if this be used as fuel, and the storage yard is accessible both by Road and Rail.

The Water Cooling and Pumping Installation (22) is so located that it can serve the Extraction Plant as well as the future Vanaspati Plant conveniently with a common Pump House housing all the water circulating pumps.

The Electrical Sub-Station is at (18), it being assumed that the High Tension power would be received on that side. Obviously, the location of the sub-station would depend upon the point of entry of High Tension supply.

The Bulk Storage Tanks for Oil (7) are so located that oil could be loaded into tank wagons in the Siding or into trucks at the filling point (24) where there is ample space for parking of trucks without interfering with other traffic.

The General Stores is at (16) with the Workshop (17) alongside. The Office Building (23) is near the main entrance to the factory and adjacent to it is the Weighbridge and Security Office (25).

It may be prudent to provide for alternate raw material to the Solvent Extraction Plant at times when beans may not be available. Provision has been made for an Oil Mill (21) conveniently located adjacent to the Preparatory Section (3) and Seed Warehouse (26) has also been provided for.

Provision for Expansion

Provision for doubling the capacity of the Bean Processing Plant is made in the factory layout. The Bean Storage Area (1) has space for 10 more silos of 2500 tons each. The Preparatory and Finishing Section (3) has provision for addition of extra equipment at the time of expanding the plant. The Solvent

Extraction Plant (4) has likewise ample space on two sides for expansion.

It is quite on the cards that a Vanaspati Plant may be added to the Project for processing at site the oil that is produced. This has also been provided for in the layout. The Vanaspati Plant proper (9), the Packing and Cooling Room (20) and the Vanaspati Warehouse (19), the Cell Room (10) for generation of Hydrogen gas, the Rectifier Room (11), the Low Pressure Gas Storage (12), the Hydrogen Compressor Room (13) and the High Pressure Cylinders (14) are all conveniently and compactly located at the bottom right quadrant of the factory area. Here also provision for doubling the capacity has been made.

Even after providing for all the foregoing, there is still adequate space on two sides of the factory for future activities.

Soybean Reception, Handling and Storage Section
Drawing No. LOT:SSS:116

Soybeans will arrive at the factory either by rail or by road. In the case of arrivals by rail, the wagon is gross-weighed on the weighbridge and shunted into the unloading warehouse(27) in which a wagon tippler is located. The tippler mechanically unloads the wagon by tilting it to one side and rocking it from end to end. This special arrangement is intended to handle closed goods wagons which have side doors. The beans from the wagon are received in a hopper at the bottom of which a belt conveyor (BC1) is located. The empty wagons are again weighed and the actual quantity of beans received in the factory is worked out and recorded.

If the beans are to be transported by road to the factory, the trucks should be of the tipper/dumper type which enable quick unloading of bulk materials by a tipping mechanism coupled with the engine of the truck. It appears that this type of trucks are being manufactured in this country by Tata Engineering & Locomotive Company Limited and by Leyland Motors. Quite apart from the special tippers, it is understood that a tipping mechanism is available in the country for about Rs.C,000/- which could be installed on any standard commercial vehicle which will enable the tipping of bulk cargo. The truck, which is weighed on the weighbridge at the entrance to the factory, drives into the unloading warehouse(27), aligns itself to the hopper provided over the belt conveyor (BC1) and quickly empties the cargo using the tipping mechanism. That done, the truck will drive away, tare weigh on the weighbridge and leave the factory.

The beans received on the belt conveyor (BC1) are taken up by the transverse belt conveyor (BC2) from which they can be diverted to either of the two elevators (E1 or E2). After being elevated to the top, they are diverted to a large capacity Pneumatic Scalper, whose function it is to effect a preliminary cleaning of the beans by elimination of trash, twigs, leaves, etc. It is always desirable to get rid of these undesirable impurities before the beans are diverted to storage. The Pneumatic Scalper(PNS) with a capacity of 2000 bushels per hour does this job effectively.

Before diverting the cleaned beans to storage, it is necessary to adjust the moisture content within permissible limits. It is reported that in countries like the USA, the moisture content of the beans at the time of harvesting is liable to be rather high and they have therefore to be dried before storage. If the beans could be harvested a little later, their moisture content would perhaps be reduced to the desired level, but they are not able to do so in view of the risk of damage to beans by frost, etc. Weather conditions in this country are somewhat different and it is believed that the beans at the time of harvesting are sufficiently dry to permit storage. However, in order to avoid any possibility of difficulties on this account, a Bean Drier of 1500 bushels per hour is also located in Head Works (2).

If drying is not required, the Pneumatic Scalper (PN8) discharges the cleaned beans on to belt conveyor (BC3) from which it is carried over to belt conveyor (BC4) or (BC5), as required, and diverted to the particular silo in which they are to be stored. If, on the other hand, drying is required, the beans from the Pneumatic Scalper (PN8) are diverted to the Drier (DYR) which is designed to reduce the moisture content from 13 to 9½%. The dried beans are received on belt conveyor (BC6), elevated by the second elevator and diverted to the designated silo via belt conveyors BC3, 4 or 5.

When the beans are to be issued for processing, the designated silo discharges on the belt conveyor below (BC7 or 8) and passes via BC6 through E1 or E2 to the Day Bin (100) via the overhead screw convoyor (OSC). If drying of arrivals is not required, charging of the silos and issues to the Day Bin (100) can be handled simultaneously. If drying is, however, required, such a simultaneous operation is not possible unless a third elevator is installed. But this appears unnecessary as issue to the Day Bin takes relatively little time and can be handled at a convenient part of the day.

<u>Preparation Drawing No. FLS:PRP:75</u>

Beans from the Day Bin (100) pass over a magnetic separator (104) for elimination of tramp iron and are received on the Vibrating Screen (101). This double decker vibrating screen eliminates foreign material, larger and smaller than the beans in size. In addition, a pneumatic arrangement lifts light impurities. If the beans are intended for commercial processing, they are elevated to the surge bin (105) and passed through the Weighing Scale (106) to the Cracker (107). If, however, the beans are intended to be processed into edible products, they are diverted to the Destoner (102) which eliminates stones, glass and other heavy impurities. The lower fraction of the discharge from Destoner is gravity pure beans which are elevated to the surge bin (105). The top fraction containing impurities are diverted to the Gravity Table (103A), where final elimination of impurities takes place. The cleaned beans discharged from the Gravity Table (103A) join the stream going to the surge bin (105).

In the crackers (107) the beans are broken into approximately 8 pieces. In this operation, the hulls get loosened from the parent material. If commercial meal is to be produced, the cracked beans along with the hulls could go forward for subsequent operations. It would, however, be preferable to pass the cracked beans and hulls through pneumatic scalper for broad separation of hulls and take beans alone for conditioning and flaking. In this case, the separated hulls are ground in a Grinder (113), toasted in a Toaster (114) and received in bins 115 & 116 from which they are added back to the defatted meal before packing.

If edible quality products are intended, separation of hulls from the beans must be complete. In this case, the mixture of cracked beans and hulls from 107 are received in a Shaker-Separator (108) from which the bulk of the hulls are aspirated into the Cyclone (109). The beans fraction is then received on a Gravity Table (103B) for complete removal of residual hulls. The pure beans from 103B then pass to the Conditioning Section.

The cleaned beans are heated and conditioned in the Conditioner (111) after which they are flaked in the Flaker (112). The flaked beans are then transported to the Solvent Extraction Plant by the Redler Conveyor (186).

Typical Layout Drawing No. LOT:PRF/80

The preparatory equipment, as described above, would generally be arranged as depicted in Drawing No.LOT: PRF:80. It will be evident from the drawing that provision of space has been made for the addition of extra machinery for doubling the capacity of the plant. The drawing also shows the arrangement of equipment for the manufacture of Full Fat Soyflour.

Solvent Extraction. Drawing No.FLS:3EP:76

The flaked beans from the Preparatory Section arrive in the Solvent Extraction Plant by the feed conveyor (186) which discharges into the feed bin (201) through the rotary valve (200). From the bin, the flakes pass into the Extractor (202). The passage through the extractor involves a soaking stage in the downward stretch of the loop, a counter-current washing stage at the bottom of the loop, a second soaking stage in the upward bend of the loop and a final washing stage with fresh solvent at the top part of the loop. After final washing, the extracted flakes pass through a draining section to the discharge bin (203) and through the solvent tight conveyor (204) to the desolventising section.

From the solvent tight conveyor (204) the extracted marc passes through the rotary valve (205) into the Desolventizer-Toaster (206). As described elsewhere in the report, the bulk of the solvent is flashed off in the top compartment of the Toaster and as the material runs down the other stages, complete removal of solvent as well as toasting operation take place. The desolventised and toasted meal is discharged into the Meal Conveyor 196 through the plug seal conveyor (207).

The miscella from the extractor (202) is received in the miscella reservoir (232); from which it is pumped into the Economiser Unit (240). In this unit, the vapours from the Desolventizer-Toaster (206), after being scrubbed in the Scrubber (210), also enter the Economiser Unit (240). The miscella is rapidly circulated in the economiser unit by means of a large capacity circulating pump. The miscella gets heated utilising the heat of the vapours from the Desolventizer-Toaster and passes into the Flasher (241), in which the miscella and the solvent vapours are separated. The pre-concentrated miscella is tapped off from the discharge of the circulating pump to the primary evaporator (233) where it undergoes further concentration and is received in the flasher (234). After separation of the flash vapours, the concentrated miscella from 234 passes into the secondary evaporator (235) for final concentration before being received in the flasher (236). The oil from 236 is finally stripped of all solvent in the final stripper (237) and then discharged to storage (238) through a pump.

The vapours from the flasher (241) and (234) are condensed in a condenser(216). The vapours from the stripper (237) are similarly condensed in a condenser (217). The uncondensed vapours from 217 are received in 216 and the uncondensed vapours from this condenser is received in condenser 211. This condenser 211 also receives the vapours from the Desolventizer-Toaster (211) via the economiser unit (240). 211 is the final surface condenser in the vapour circuit.

The uncondensed gases from 211 pass through a contact condenser (212) to the adsorber (213) where the solvent vapours are adsorbed in an oil medium. Thereafter the residual gases are vented to atmosphere.

The condensate from the economiser unit (240) and condensers (217, 216 and 211) are received in a water solvent separator (218). The separated solvent overflows in the solvent reservoir (231) from which it is recycled to the process. The water separated in the water solvent separator is received in the effluent flasher (219) where solvent vapours, if any, are flashed off and recovered and the water is discharged to sewer.

In the solvent recovery system, vegetable or mineral oil is used as a medium for adsorption and recovery of solvent vapours from the vent gases. After adsorbing solvent in the adsorber (213), the solvent-laden oil is stripped of solvent in the solvent evaporator (214) cooled in a solvent cooler (215) and returned to the adsorber. The oil is recycled in the recovery system similar to a refrigerant in a refrigeration system.

Progressively increasing vacuum is maintained in the miscella evaporation system by means of a series of steam evacuators shown on the drawing. Also, sub-atmospheric pressure is maintained throughout the plant.

Typical layout of Extraction Plant - Drawing No.LOT:SEP:81.

Typical layout of the solvent extraction plant as described above is depicted in Drawing No.LOT:SEP:81.

Finishing Section Drg. FLS:FIN:89

The defatted meal from the Dexanizer-Toaster in the solvent extraction plant is transported to the Finishing Section by the Meal Conveyor (196) and dumped into the Intermediate Meal Bin (350). The conveyor (196) is of the ventilated type so that partial cooling of the meal is achieved. From the bin (350), the meal passes on to the Vibrating Screen No.1, which generally has 16 mesh screen. The material passing through the screen is diverted to the Meal Cooler (353). The material passing over the screen is received in Grinder No.1, which is generally a low speed grinder. The product after grinding is received in Vibrating Screen No.2 which generally has 14 mesh screen. The material passing through is as usual diverted to the Meal Cooler (353). The material passing over the screen is received in Grinder No.2, which is a high speed grinder, which will completely pulverise all the material to the required mesh.

The ground meal from the preceding section is well cooled in the Meal Cooler (353) and after cooling the material is received in the Intermediate Meal Bin (356). From this bin, the finished meal enters the Mixing Screw Conveyor. The dockage from the cleaning equipment in the Preparatory Section (except metal, glass, etc.) is ground and received in Bin No.115. The ground and toasted hulls from the Preparatory Section is stored in Bin No.116. In the case of commercial quality 44% meal, it is customary to add back the dockage and the hulls to the meal. This is effected by dosing in the dockage and the hulls into the Mixing Screw Conveyor. Thereafter the product goes to the automatic Bagging and Weighing machine. Weighed bags are moved over a short belt to the sewing machine for the closure of the mouths. Thereafter, the bags go to storage.

If Soygrits and Soyflour are desired, they could also be produced with some minor variations in the process. Depending on the size of grit required, Screen No.2 is adjusted and what passes over the screen is collected as grits. When Soyflour of fine mesh is desired, the material coming out of the Grinding Section is further pulverised in Micro Pulverisors before cooling in the Meal Cooler 353. Thereafter, the meal is handled in a ribbon conveyor where the required quantity of fat or lecithin may be dosed in. The final product is packed as usual.

PROCESSING SOYBEANS IN EXISTING EXTRACTION PLANTS

Quite apart from the creation of new processing facilities, it is but natural that the existing facilities should be utilised wherever possible for processing soybeans by the addition of supplementary equipment.

Basically only modern continuous solvent extraction plants are suitable for processing soybeans. About half of the total number of extraction plants in the country are of the continuous type. About 60 plants will lend themselves to conversion for processing soybeans.

Modern extraction plants processing expeller cakes would require the following additional equipment in order to enable them to process commercial quality soybean meal:

		Estimated Price. Rs.
1.	Bean Cleaning equipment	50,000
2.	Bean Conditioner	45,000
3.	Flaker	100,000
4.	Toaster	65,000
5.	Grinding & Sizing equipment	85,000
		345,000
6.	Modifications, erection and installation	55,000
	TOTAL ...	400,000

The above estimates are based on handling 100 Tonnes/24 hours of soybeans with minimum of additional equipment.

EXHIBIT 'A' - EXTRACTION PLANT - The French Oil Mill Machinery Co.,
PIQUA, OHIO, 45356, U.S.A.
11-1-1966.

INSTALLATION COSTS OF SOYBEAN SOLVENT EXTRACTION PLANTS:

	200 Tons.	300 Tons.	500 Tons.
1. Processing equipment, starting with bean cleaner and bean scale, including production of 50% protein meal, design and engineering and supervision of the installation and start-up	$ 490,000(1)	$ 605,000(1)	$ 780,000(1)
2. Installation of equipment, including freight, foundations, extraction, preparation and meal grinding buildings, boiler and boiler house, bean day bin, oil storage (one week) and meal storage (two days).	$ 330,000(2)	$ 413,000(2)	$ 550,000(2)
3. Total installed cost of processing equipment. Does not include land; bean unloading, drying or storing; service buildings; roads, fence, railroads, transformers; cost of bringing utilities to the area; fire protection; taxes.	$ 820,000	$1,018,000	$1,330,000
4. Bean unloading, drying, conveying and storage.	$ 640,000 (800,000 bu.)	$ 800,000 (1,000,000 bu.)	$1,500,000 (2,000,000 bu.)
5. Approximate total installed cost. Does not include land, service buildings, roads, fence, railroad tracks, cost of bringing utilities to the area, fire protection or taxes.	$1,600,000	$2,000,000	$3,000,000

Unit Cost Figures

1. Railroad trackage costs about $14. per foot, not including fill.
2. Cyclone fence, 6 ft. high costs about $5. per foot.
3. A deluge fire protection system for the extraction plant costs about $20,000. About 1500 g.p.m. of water at 90 Psig. must be supplied.

(1) For 1970 add about 10% to equipment prices, add 20% for export crating and inland and ocean freight and insurance.
(2) Installation costs are up about 25% in the U.S., but costs in India should be less because of lower labour cost. Figures shown may be as good as any.
(3) For 100 Ton capacity, use 75% of 200 Ton figures.

EXHIBIT 'A' - EXTRACTION PLANT - The French Oil Mill Machinery Co.,
PIQUA, OHIO 45356, U.S.A.
May 18, 1970.

Specification of Extraction and Desolventizing Equipment for Soybeans to Produce Crude Edible Oil and Meal for Animal Feed.

Tons per day	100	250	500
1. FRENCH Stationary Basket Extractor			
Size	#310	#319	#419
Feed conveyor with plug seal - Size	9"	12"	14"
- HP	1½	2	3
Extractor drive - HP	1	1	1
Picker drive - HP	1	2	2
Note that specifications include motors and drives, sight and light glasses, internal piping, solvent and miscella distribution system.			
2. Stage pumps, including solvent pump, and full miscella pump	5	6	6
3. Spent flake conveyor-mass flo type-HP.	3	7½	10
4. Seal convoyor - size	9"	12"	14"
- HP	2	3	5
5. Desolventizer-Toaster			
A. Unit. - Kettles - number	4	8	4
- intermediate height, inches	34	36	36
- top kettle height, inches	48	50	72
Diameter, inches	85	100	100
Speed reducer Frenco-	29"	11NT8	9NT8
H.P.	40	100	75
B. Vapor scrubber - diameter	48"	60"	72"
C. Rotary discharge valve	None	8"	8"
D. Piping, valves, fittings and traps	Yes	Yes	Yes
6. Conveyor to meal dryer- mass flo type-HP	None	None	5
7. Rotary steam tube meal dryer- size	--	--	6'x30'
- HP	--	--	15
PRICE, FAS, NYC, Crated for Export -	$149,000	$235,000.	$265,000.

The above does not include preparation equipment, conveying to the extractor or away from the extraction area, solvent or oil recovery equipment, instruments, electrical wiring or lights or motor controls, insulation, access platforms or structural supports, utilities, ocean freight, taxes or duty.

EXHIBIT 'B' CROWN SOLVENT EXTRACTION PLANT:

Information furnished by: DU-VAL Industrial Foreign Trade Corporation, DALLAS, TEXAS 75205, U.S.A.

Enclosed we are sending you a typical quotation for a Crown plant for direct extraction of soybeans. The price for a complete plant as described in the typical quotation (the size of the extractor and of the desolventizer-toaster will of course vary with the capacity) is as follows:

A.	100-ton Plant	$ 180,000.00
B.	250-ton Plant	$ 210,000.00
C.	400-ton Plant	$ 264,000.00
D.	600-ton Plant	$ 304,000.00

If you wish to buy an extractor and a D-T only and build the separation equipment locally, the following prices will apply as per our cable:

		Extractor	Desolventizer-Toaster
A.	100-ton	$ 60,000.00	$ 42,000.00
B.	250-ton	$ 77,000.00	$ 51,000.00
C.	400-ton	$102,000.00	$ 61,000.00
D.	600-ton	$119,000.00	$ 78,000.00

EXHIBIT 'B' (Cont'd)

A TYPICAL SPECIFICATION - CROWN SOLVENT EXTRACTION PLANT:

Information furnished by: DU-VAL Industrial Foreign Trade Corporation,
5421 North Central Expressway,
DALLAS, TEXAS 75205, U.S.A.
their Export Agents.

CROWN SOLVENT EXTRACTION PLANT FOR 250 TONS OF SOYBEAN

One (1) Crown Series 250 immersion and percolation type extractor, approximately 3' wide x 33' long x 28' high, including all necessary pumps, motors, and flowmeters. A variable drive is controlled by an Accuray nuclear sensor for proper flake level control. A flake inlet hopper for mounting the Accuray will be furnished which can be made to fit specifications as to height. This extractor will be completely fabricated and pre-assembled in Crown shops to assure accurate assembly in the field. All piping and valves for the extractor will be furnished. We will pipe the extractor in our shop, mark the pieces and disassemble for shipment.

One (1) Crown desolventizer-toaster, 102' diameter, six trays high with top tray 48" deep and the remaining four trays 30" high. Sparge steam through sweep arms in top kettle. Sweep arm wear points are stellited for wear resistance. Tray vent close coupled and made of stainless steel. Main drive thrust bearing frame mounted on desolventizer-toaster for proper shaft alignment and longer wear. Jones vertical shaft speed reduction drive, 75 H.P. motor direct coupled. Fabricated steel motor and drive base. Desolventizer supports and anchors.

One (1) Crown centrifugal solvent spray vapor wash with non-clogging vapor duct mounted directly on desolventizer-toaster.

One (1) Suction type combination meal cooler and conveyor including high velocity cyclone with replaceable wear plates, rotary seal, drive; blower fan, base, drive and motor; meal conveyor tubing and air duct. 100 feet maximum distance to be conveyed. An extra charge will be made for any distance over 100 feet.

One (1) Special hot meal conveyor to carry meal from the desolventizer-toaster to meal cooler, complete with drive.

One (1) Wet meal vapor tight conveyor system to carry solvent wet meal from the extractor to the desolventizer-toaster, including hopper, spouts, drive, and mounting.

EXHIBIT 'B' (Cont'd)

One (1) First stage evaporator built with stainless steel tubes to use heated vapors from desolventizer-toaster and steam from vacuum ejectors to remove solvent from oil, including float valves, pump, and fitted with a swirling vapor dome.

One (1) Stripping column, Crown jacketed disc and donut type, including float valves, oil pump, and vacuum ejector, and fitted with a demisting type vapor dome.

One (1) Crown hydroclone miscella clarifying system, including flow-meters, high pressure pumps, and miscella tank.

One (1) Vertical type desolventizer condenser built with stainless steel tubes and baffles.

One (1) Four-pass horizontal type evaporator condenser built with stainless steel tubes and baffles, sized to operate under partial vacuum for steam economy.

One (1) Crown solvent air separator system complete with stripping column, absorption column, mineral oil heater, mineral oil cooler, pumps, flowmeters, gauges and vacuum ejector

One (1) Combination solvent work tank and solvent water separating decanter including recycle pumps, solvent pump, and flowmeters.

One (1) Waste water reboiler to remove solvent traces from waste water.

All necessary solvent and miscella preheaters as well as miscellaneous pressure, temperature gauges, ejectors.

All valves, pressure regulators, traps, safety valves, and pressure gauges for our extraction equipment.

All motors will be Class I, Group D, explosion-proof.

We will furnish such engineering layouts and drawings as are required for the proper installation of the proposed equipment and make preliminary plant layouts. A schematic flow sheet will be provided for piping the equipment.

We do not furnish steam, water, solvent, vapor or oil piping; fittings, drain piping, except as noted, electrical wiring; switches; erection labor or tools, foundations, insulation, grinding or sacking equipment, building structures, solvent, oil or meal storage.

Guarantees:

Capacity: 250 tons of soybean per 24 hours.

EXHIBIT 'B' (CONT'D)

Guarantees: (Cont'd)

Meal: Extracted meal shall contain less than 1% residual oil by weight on a 12.5% moisture basis and shall be commercially free of solvent.

Oil: Extracted oil shall have a closed cup flash point of 300°F. or higher.

Solvent: If plant is operated in the rated guaranteed capacity in accordance with good operating practices, the solvent loss shall not be more than .4% of the weight of the material processed.

Steam: Steam requirement shall not exceed 900 lbs. @ 125 P.S.I. per ton of material processed.

Water: Water requirements shall not exceed 300 G.P.M. of 60° well water or 900 G.P.M. of water from cooling tower colled to within 7° of wet bulb temperature.

Shipment: Shall be completed in approximately six months.

TOTAL PRICE NET FAS U.S. PORT................$210,625.00

This proposal is guaranteed for sixty days, after which the price is subject to review.

EXHIBIT 'C' - CRACKERS & FLAKERS - Ross Machine & Mill Supply Plant, P.O. DRAWER 26468, OKLA. CITY, OKLA. 73126, U.S.A.

ROSS TWO-PAIR HIGH CRACKING MILL, furnished with solid roll type feeder, V-Belt differential drive and guard, split housing for easy roll removal, soybean rigid feed gate and Ross-A-Matic feed roll drive, 2-7/16" journals double row spherical roller bearings with tapered adapter:

				Price: Unit.	Total.
100 Tons/24 hrs.	ROSS	10x30	1 No.	$ 5520.00	$ 5520.00
250 Tons/24 hrs.	"	10x30	2 Nos.	$ 5520.00	$11040.00
500 Tons/24 hrs.	"	10x36	3 Nos.	$ 6030.00	$18090.00

ROSS HYDRAULIC FLAKING MILL, furnished with base extension, heavy duty V-Belt differential drive and guard, vibratory feeder, split main housing for easy roll removal, hydraulic power unit with pump and motor, accumulators, hydraulic control and fittings, Turn Tuff Rolls ground to customer specifications, 5-15/16" journals in the bearing area and double row spherical roller bearings:

100 Tons/24 hrs.	ROSS	20x30	1 No.	$16310.00	$16310.00
250 Tons/24 hrs.	"	20x42	2 Nos.	$17805.00	$35610.00
500 Tons/24 hrs.	"	20x42	3 Nos.	$17805.00	$53415.00

PRICES F.O.B. OKLAHOMA CITY - BOXED FOR EXPORT.

EXHIBIT 'D' - CLEANING EQUIPMENT - FOSBERG INC.,
THIEF RIVER FALLS,
MINNESOTA 56701, U.S.A.

Cleaning System is basically comprised of four pieces of machinery - the Pneumatic Scalper, the Screener or Screen-Aire, the Destoner, and the Gravity Table. Their purpose is as follows:

Pneumatic Scalper - first in the receiving line to remove dust, dirt, leaves, twigs, etc.

Screen-Aire - to scalp off all foreign material larger than the soya bean and to remove all products smaller than the soya bean through the bottom screen, such as sand and other heavy fines. This unit can be used either with or without the aspirator unit. The aspirator unit on the end of the machine does however, remove more dust and dirt through the air liftings as well as to remove lighter, inferior product which we will call settlings.

Stoner - the purpose of this machine in the flow line is to remove all stones, metal, glass and any other foreign material that may happen to be the same size as the soya bean. This machine also contributes greatly to the capacity of the entire flow line by enabling to send the bottom portion of the bed of material on the Destoner, which usually is gravity pure, to finished-product bin. Then the top cut, in this case arbitrarily set at 40%, which contains most of light product and lighter impurities, is set to the Gravity Table for final finiching.

Gravity Table - this machine does the final job of making the moredifficult separations, i.e. separating good product from foreign matter that has a close specific gravity. We do also make Gravity Tables in totally enclosed vacuum type models that provide a dust free operation.

SOYA BEANS - 3 LINES

"A"	100 tons per 24 hour day = 8,400 lbs./hr. = 150 bu./hr.
"B"	250 tons per 24 hour day = 21,000 lbs./hr. = 360 bu./hr.
"C"	500 tons per 24 hour day = 42,000 lbs./hr. = 750 bu./hr.

Line "A" 100 Tons/24 hrs.	Line "B" 250 Tons/24 hrs.	Line "C" 500 Tons/24 hrs.
458 Pneumatic Scalper	458 Pneumatic Scalper	458 Pneumatic Scalper
24 x 48 Screen-Aire or Screener	46 x 48 Screen-Aire or Screener	60 x 84 Screen-Aire or Screener
40%	40% (8,400 lbs.)	40%
H-4 Destoner (vacuum)	H-8 Destoner	2 - H-8 Destoners
G-4 Destoner (pressure)		
10-M Gravity Separator (to handle 3,360 p.p.h.)	2 - 12-M Gravity Separators.	3 - 12-M Gravity Separators (16,800 lbs./hr.)
$ 8,495	$ 13,970	$ 22,978

F.O.B. Thief River Falls, Minnesota, U.S.A.

FOR THE BEAN STORAGE SECTION:

PNEUMATIC SCALPER, Model 668, to handle
2000 bushels per hour without fan & motor ... $ 1,354.00

EXHIBIT 'E' - BEAN DRIERS - AEROGLIDE CORPORATION,
6300 HILLSBORO ROAD,
RALEIGH, NORTH CAROLINA 27602, USA.

AEROGLIDE continuous flow soybean drier for reducing moisture content of beans by 3.5% (13.0 to 9.5%) from clean, unfrozen soybeans complete with:

Pre-welded modular tower sections with hot air and exhaust air duct system;

Fan house with separate control room and walk-in doors;

Backward-curved, heavy-duty industrial fan;

Manually operated Climate Compensator for varying drying and cooling air ratio to give maximum capacity under prevailing weather conditions;

Top and bottom inspection doors;

Fill cap and discharge hopper assembly;

With low grain level indicator;

Drop-bottom Power Discharge with eight self-cleaning rotors and one 1/2 H.P. TEFC 3/460/50 variable speed power unit for adjusting discharge rate to suit grain conditions;

Oil burner for fuel oil (CS12-48 standards) complete with oil circulating pump, automatic operating and safety controls, combustion chamber and refractories;

Factory pre-wired dust-tight control panel with start-stop push-button stations and indicating lights;

Access ladder and service platform;

Fan drive arrangement complete with sheaves, bushings and V-belts, but <u>less</u> motor and base;

Standard operating and safety controls including temperature limit switches for hot and exhaust air ducts, thermostat controller and flame supervisory system;

5 metric tons/hour with 30 H.P. TEFC 3/460/50/1500 motor premounted on drier fan, NEMA Size 3 across-the line magnetic starter including overload heaters and start-stop, push-button station pre-wired into control panel. .. .. .. $ 22,052.00

12.4 metric tons/hour with 60 H.P. Motor and Starter. .. .. .. $ 40,378.00

24.9 metric tons/hour with 60 H.P. Motor and Starter. .. .. .. $ 68,160.00

XHIBIT 'E' - BEAN DRIERS - CAMPBELL INDUSTRIES, INC.,
3121 DEAN AVENUE,
DES MOINES, IOWA 50317, USA.

CAMPBELL continuous flow grain dryer for reducing moisture content from 13 to 9½% at 200°F air temperature including:

GRAIN TOWER, weatherproof construction, reinforced for self-support in 100 mph. wind, with UNI-FLOW dividers to prevent cross flow of grain; multi air duct grain tower design for most uniform drying of grain; hand hole access doors into each air duct in grain tower; complete alarm system with a thermostat in every air discharge opening to shut down dryer and sound alarm if exhaust temperature is excessive; access ladders; mechanical unloader with fluted rolls and 1/3 H.P. motor and drive.

DRYER UNIT completely pre-assembled, factory test-fired unit with fans, burner and controls; 36½ SWSI backward inclined blade, non-overloading centrifugal, drying fan with volume damper, cooling fan on same shaft, Hauk air-atomizing fuel oil burner for 85 SSU viscosity (minimum) fuel oils; 5:1 turn down ratio, 5,000,000 Btu/Hr maximum burner capacity; fuel oil manifold with solenoid safety valve fuel pressure regulator, fuel filter and fuel pressure switch; Gas pilot and manifold with electric ignition, solenoid valve, and gas pressure regulator; fuel pump V-belt driven by combustion air fan, pressure relief valve and strainer; combustion air fan with V-belt drive; combustion air manifold with volume damper and air pressure switch; control panel to include drying air temperature indicator/controller, ultra-violet main flame supervision, electronic pilot flame supervision, electronic flame controlled relay, drying air flow switch, high drying air temperature limit switch, grain flow control; motor control panel, etc.

250 Tons/24 Hours	..	$ 15,926.00
500 Tons/24 Hours	..	$ 21,250.00

PRICE: C.I.F. Indian Port.

<u>EXHIBIT 'E'</u> - <u>BEAN DRIERS</u> - A.T. FERRELL & COMPANY,
1621 WHEELER STREET,
SAGINAW, MICHIGAN 48605, USA.

CLIPPER GENIE DRYER, OIL-FIRED:

300 bushels per hour	(200 Tons/24 [illegible] ..	$ [illegible]0,430.00
750 bushels per hour	(500 Tons/24 Hours) ..	$ 26,670.00
1500 bushels per hour	(1000 Tons/24 Hours) ..	$ 41,950.00

<u>PRICE</u>: Boxed for Export, F.O.B. Saginaw.

EXHIBIT 'F' - BAGGING & SEWING - HOWE RICHARDSON SCALE COMPANY,
680 VAN HOUTEN AVENUE,
CLIFTON, NEW JERSEY 07015, U.S.A.

100 to 250 tons/24 hours:

One (1) Howe Richardson model GA-17 Belt Fed Automatic Gross Bagger with a speed of up to 4, 50 kgs. or 100 kgs. bags per minute; having an accuracy of within 2 sigma plus or minus 120 to 180 grams. Arranged for operation on 230 volts, 50 cycles, 3 phase.

Price:	Export packed F.O.B. Clifton, N.J.	..	$ 2496
	Inland freight F.A.S. N.Y.	..	18

One (1) Howe Richardson Uni-Pak Bag Closing and Conveying System consisting of a 6' - 6" long variable speed conveyor with 12" wide 3 ply rubber covered canvas belt, adjustable height sewing pedestal and model 80600E heavy duty sewing head. Arranged for operation on 230 volts, 50 cycles, 3 phase. This system to be used in conjunction with the above scale.

Price:	Export packed F.O.B. Clifton, N.J.	..	$ 1777
	Inland freight F.A.S. N.Y.	..	18

500 tons/24 hours:

One (1) Howe Richardson model E-5010A Automatic Bagging Scale consisting of a belt feeder, 4 cubic foot capacity weigh hopper, discharge hopper, and model G-30 air operated dust-tight bag holder. The scale will have a speed of up to 15, 50 kilo bags per minute or 8, 100 kilo bags per minute having an accuracy of within 2 sigma plus or minus 120 grams. It will be arranged for an operation on 230 volts, 50 cycles, 3 phase.

Price:	Export packed F.O.B. Cliften, N.J.	..	$ 6995
	Inland freight F.A.S. N.Y. vessel	..	40

One (1) Howe Richardson model GA-11 bag sewing conveyor having a length from 7' - 12' (adjustable in 4" increments); 12" wide rubber canvas belt; and a variable speed from 25' - 42' per minute. Arranged for operation on 230 volts, 50 cycles, 3 phase.

Price:	Export packed F.O.B. Clifton, N.J.	..	$ 1348
	Inland freight F.A.S. N.Y. vessel	..	16

EXHIBIT 'F' (Cont'd)

One (1)	Howe Richardson model G-25A sewing pedestal complete with model 80600E Union Special heavy duty sewing head; sewing pedestal with a vertical height adjustment from 20½" minimum to 48" maximum; horizontal adjustment range of 8"; the sewing head is supplied with a variable speed sheave so that it can be synchronized with the speed of the bagging conveyor. Arranged for operation on 230 volts, 50 cycles, 3 phase.

Price:	Export packed F.O.B. Clifton, N.J.	..	$ 1657
	Inland freight F.A.S. N.Y. vessel	..	16

EXHIBIT 'G' - SOLVENT EXTRACTION PLANT - DE SMET (INDIA) PRIVATE LTD.,
KHANNA CONSTRUCTION HOUSE,
44, MAULANA ABDUL GAFFAR ROAD,
WORLI, BOMBAY-18 WB.

	100 T. Plant.	250 T. Plant.	500 T. Plant.
Preparatory Section	6,10,000/-	11,95,000/-	23,00,000/-
Extraction & Desolventising Section	8,52,000/-	16,75,000/-	33,00,000/-
Distillation Section	4,50,000/-	8,80,000/-	16,00,000/-
Conditioning Section	1,80,000/-	3,00,000/-	4,85,000/-
Total Rs.	20,92,000/-	40,50,000/-	76,85,000/-

SPECIFICATION NO. 70/01/02/SEP:

Item	Quantity.	DE SMET CONTINUOUS EXTRACTION PLANT.
		PREPARATORY GROUP
EI	1	FEED ELEVATOR FITTED WITH MAGNETIC DRUM for raw materials, totally enclosed type fitted with inspections doors and elevator chain complete with driving mechanism comprising of TEFC motor and starter. Magnetic drum complete with rectifier unit.
703	1	CORRUGATED ROLLER MILL Totally enclosed type with larger inspection doors fitted with single pair of chilled cast iron hard corrugated rollers supported on heavy roller bearings. Machineries are complete with driving mechanism, fitted with special belliville spring washers to take care of shock heating.
HSP	1	HUSK SEPARATOR with necessary aspiration arrangements for removal of husks.

Specification (Cont'd)

Item.	Quantity.	
707	1	TEMPEROR In M.S. welded construction with jacketed shell with conveying paddles fitted on rotating shaft mounted on heavy duty roller bearing with necessary live steam injection device, complete with driving mechanism.
708	1	DE SMET COMBINED CRISPER CHAIN CONVEYOR for crisping the raw materials by indirect heat of steam with jacket bottom and with an arrangement for steam injection with scrappers in each stage by central shaft. Each stage provides with vapour tight inspection roller and the item is complete with driving mechanism.
704	1	FLACKING MACHINE totally enclosed type fitted with smooth chilled cast iron rolls supported on large roller bearings with adjustable scrapers for roller cleaning and with special devices for adjusting rolls distance fitted with belliville washers to avoid damage to the rolls in case of accidental passage of hard foreign material. Complete with driving mechanism.
708	1	DE SMET REDLER TYPE CHAIN CONVEYOR for maximum length 25 meters is fitted with special conveyor chain and fitted with alloy steel wearing straps. Special arrangements provides to cool the material simultaneously as it is being conveyed. Complete with driving mechanism.
736	1	FORCED DRAFT DEVICE Comprising fan, TEFC motor, V-belt driving mechanism air conducting pipe with adjusting slide and starter.
714	1	CYCLONE of special construction for recovering eventual dust produced during cooling process with connecting air pipes and supports.
705 D	1	ROTARY VALVE to be mounted under the cyclone.
57		Necessary connecting air pipes and ductings.
OE	1	Necessary transport equipment inside the preparatory sections.

Specification (Cont'd)

Item	Quantity.	
		EXTRACTION GROUP:
8a	1	INLET ROTARY VALVE for feeding the raw material to extractor to complete with chain drive and driving mechanism.
2	1	FEED HOPPER of welded mild steel construction.
2a	2	BINDICATORS EP, fitted in item 2 above, with actuating liner for blowing horn to warn the operators about the low or high level raw material.
3	1	DE SMET CONTINUOUS EXTRACTOR, Type (18-12-9) with miscella hoppers, circulating pumps (p3) with E.P. motor, piping, atomizer, plug, valves, sampling valves, heaters, rinsing device with automatic syphon, manholes and sight glasses, driving arrangement with varispeed device, including E.P. motor, gear box and drive. This unit fitted with rotary brushes, rotary scraper, special mechanical seals, complete band conveyor comprising cover joints, perforated plates, metal cloth and special links. Type Spcl (250/500)
5	1	SOLVENT-TIGHT INTERMEDIARY MEAL CHAIN CONVEYOR - fitted with special alloy steel wearing straps, special conveying chain including gear box with EP motor.
8b	1	INTERMEDIARY ROTARY VALVE fitted with special mechanical seal, chain drive, driving mechanism.
70	1	DESOLVENTISER TOASTER in mild steel construction, with jacketed bottom for indirect heating of the material with steam, comprising of number of stages, each stage fitted with inspection door, scraper and feed regulator all governed from central shaft, complete with driving mechanism.
8c	1	JACKETED ROTARY VALVE fitted with special mechanical seal, chain drive, driving mechanism.

Specification (Cont'd)

Item	Quantity.	
28	1	DRY DUST CATCHER - where applicable of welded mild steel construction, including driving mechanism with gearbox and E.P. motor.
29	1	WET DUST CATCHER - in mild steel construction fitted with sprayers, sight glasses and safety syphon, to wash the vapours from the desolventising unit with hot water for removing dust.
20a	1	HORIZONTAL SURFACE CONDENSER
20b	1	shell in mild steel construction and tube system in Brass complete with supports, floating head type for easy removal of tubular bundle.
30	1	FINAL GAS COOLER in mild steel construction with atomizer to scrub the uncondensed vapours with cold water for contact condensing.
45	1	SAFETY WASTE WATER DESOLVENTISER fitted with sight glasses, manhole, heating coil and thermostat to control the temperature of outgoing waste water at 80° to 90°C, in mild steel construction.
		DISTILLATION GROUP
17	1	MAIN MISCELLA TANK AND DECANTER of welded mild steel construction, with manholes and supports, including level distance indicator.
18a	1	DE SMET MISCELLA STILL working on the rising film principle, shell in welded mild steel construction and tube system in mild steel with supports.
18b	1	SEPARATOR for ensuring that no oil goes along with solvent vapours in M.S. fitted with sight glass.
19	1	HORIZONTAL SURFACE CONDENSER, shell in mild steel construction and tubes system in brass, complete with supports, floating head type, for easy removal of tubular bundle.

Specification (Cont'd)

Item	Quantity	
21	1	OIL HEATER - shell in mild steel construction and tube system in mild steel for raising the temperature of the oil with thermostat valve to control the temperature of the oil.
22	1	STRIPPING COLUMN - shell in mild steel construction fitted with mild steel internals, with sight glasses, supports and atomisers for spraying the oil.
23	1	SURFACE CONDENSER - Shell in mild steel construction and the tube system in brass with supports, floating head type for easy removal of tubular bundle.
32A/B	1	MAIN AND SAFETY WATER SOLVENT SEPARATOR in mild steel for separating pure solvent from water received from condensers by gravity decantation.
34	1	SOLVENT RECEIVER in mild steel construction to receive fresh solvent from item 32A/B prior to transferring the same to extractor.
41	4	STEAM EJECTORS for maintaining vacuum on condenser and apparatus to ensure vacuum distillation and stripping and for effecting economy in steam. NOTE: Items 17-32A/B-34 and 45 are combined in a single vessel with several compartments.
60A	1	STEAM ECONOMISER UNIT De Smet Economiser Unit for the effective utilisation of the heat of vapours coming out from Desolventising section for heating up miscella before being fed to the distillation section. Shell in M.S. construction tubular bundle in cupronickel fitted with necessary nozzles and supports.
60B	1	SEPARATOR FOR ECONOMISER
120	1	SOLVENT RECOVERY GROUP SPECIAL RECUPERATING UNIT WITH stainless steel 'internals' fitted with mechanical seal, along with EP motor, EP push button, gear box and complete drive. Shell construction in mild steel; for absorbing the solvent vapours from the vent air to minimise the solvent loss.

Specification (Cont'd)

Item	Quantity	
180	1	ABSORBING MISCELLA EVAPORATOR in mild steel construction working under vacuum, complete with motor and drive to recover the solvent from the oil.
181	1	SURFACE COOLER for cooling the absorbing oil after distillation with double coils in heavy gauge pipes.
		ACCESSORIES:
50		ALL THE WATER VALVES
51		ALL THE SPECIAL VALVES FOR SOLVENT, MISCELLA AND OIL CIRCUIT
52		ALL THE STEAM VALVES
54		ALL THE MILD STEEL PIPES WITH FLANGES, GASKETS, BOLTS, NUTS AND BENDS.
56		ALL THE STEAM TRAPS WITH STRAINERS, SIGHT GLASSES AND AIR VENTS.
58		CONTINUOUS DUTY CENTRIFUGAL PUMPS specially designed to handle pure solvent, miscella, oil etc., required in the plant with specially designed mechanical seals, with base-plate and drive and E.P.motor and push buttons.
		PI - For transferring fresh solvent from item 34 to the extractor - item 3.
		P2 - For transferring the back washed miscella from the hopper to the extractor.
		P3 - Set of pumps to circulate miscella of different concentration in the extractor for counter-current washing.
		P8 - For transferring miscella from miscella tank to the distillation columns.
		P15 - For transferring miscella from extractor to the Miscella Holding Tank.
		P18 - For transferring concentrated miscella (oil) from evaporator to the stripping column.

Specification (Cont'd)

Item	Quantity	
		P19 - For transferring condensate from vacuum condensers to the solvent miscella separators.
		P22 - For transferring final stripped oil to the storage.
		P29 - For circulating hot water from Dust Catcher to the Waste Water Boiler for scrubbing the gases.
		P180 For circulation of absorbing oil in the recuperation system.
		P63 - For transferring solvent from solvent storage tanks to the plant.
		P60 - Forcirculation of miscella in the economiser unit.
62		SPECIAL MEASURING AND AUTOMATIC SAFETY CONTROL DEVICES:
		a - Miscella Flowmeter to control the flow of miscella to distillation column.
		b - Steam Reducing Valve to control the pressure of steam in distillation section.
		c - Automatic temperature regulator as described supra, for controlling the temperature of final oil and waste water from the plant.
		d - Motorised Steam Valve (electrically actuated steam valve) in E.P. construction to cut off the steam automatically supplied to the entire plant in the event of power failure or in the event of failure of cooling water supply.
		e - Electrically actuated Thermostat to warn the operators by visual and audible signs in the event of excess vent temperature and inter-locked with motorised steam valve to cut off the steam supply.
		f - Pressiostat - electrically operated to stop the plant entirely in case of steam failure in the Desolventisers, thus eliminating the chances of undesolventised meal going out to the packing.
		g - Underpressure indicators.
		h - Special dial thermometers.
		i - Pressure and Vacuum Gauges

Specification (Ctd..)

Item	Quantity	
		j - All guards for driving mechanism
		k - Lubricating devices, with grease nipples, oil cups and grease gun.
		l - All sight glasses for the piping
		m - 2 sets of spark-proof tools required during maintenance of plant.
		n - Caution Boards.
72		All E.P motors for the driving mechanism and pumps to be installed in the extraction building as hereabove mentioned.
73A		COMPLETE SWITCHBOARD with enlightened sketch of the plant, fitted with ammeter and control lamps, starters, fuses for the apparatus mentioned hereabove, equipped with sequencing of operations, visual and audible indicators for faults, if any, developed in the process with interlocking system of safety devices.
73B		All E.P PUSH BUTTONS AND SAFETY SWITCHES for motors and light fixtures of the plant.
73B		AUTOMATIC SAFETY DEVICE WITH HORN AND VISUAL SIGN warning operators in case of motor failure.
75		EP CABLES AND LIGHT FIXTURES for general lighting of the building and internal lighting of apparatus.
97		OPEN AIR TYPE STEEL STRUCTURE for main Solvent Extraction Plant with all supporting structures, platforms, steel floors, trusses and pentroofs, gangways, stairs and railings, columns for supporting a corrugated asbestos type roof and anchorage bolts and extra staircase, but WITHOUT asbestos sheets for the roof and pentroofs and foundations.

NOTE: 1. The quantities against Accessories will be supplied in accordance with our preferred arrangement for the above capacity plant.
2. The term "Explosion-proof" as used here is synonymous with the term "Flame-proof".

Specification (Contd')

Item	Quantity	
		CONDITIONING AND CONVEYING SECTION
9	1	MEAL COOLING CONVEYOR - Max. length: 25 metres fitted with special device ensuring the cooling of the meal by air and conveying chain including TEFC motor, gear box, chain drive, driving mechanism.
14	1	DRY CYCLONE in mild steel construction for recovering eventual dust produced during cooling process, with connecting air pipes.
8d	1	ROTARY VALVE to be mounted under the cyclone.
36	1	AIR FAN ensuring the aspiration of the cooling air through cooler conveyor, including air ducts, with adjustable sliding doors, V-belt driving mechanism, TEFC motor.
39	1	FINAL WET CYCLONE in mild steel with sprayers and supports.
II	1	DE SMET TWIN SCREW HUMIDIFIER in welded mild steel construction with supports, stainless steel cover spraying device, water flowmeter, including TEFC motor and gear box and drive.
		GRINDER for grinding the meal to suitable mesh complete with driving mechanism.

REMARKS: We reserve the right to alter the specifications, wherever found necessary, in the light of later developments subject to the condition that the overall performance of the equipment remains unaltered.

DE SMET CONTINUOUS EXTRACTION PLANT

WARRANTY

CAPACITY: expressed in metric tons/24 hours.

Nature of Material	Oil Cont.	Min. Capacity
SOYBEAN SEEDS	18 to 20%	250

The plant will be able to run satisfactorily at capacities of 20% above these figures, but warrantees of deoilings and solvent losses will not apply in this case.

RESIDUAL OIL CONTENT OF EXTRACTED MEAL:

SOYBEAN SEEDS	Less than 1%	Practically 0.7%

Analysis to be made with the solvent utilised in the extraction plant following official AOCS METHOD.

SOLVENT CONSUMPTION:

SOYBEAN SEEDS.	Less than 0.7%	by weight of entering material.

All Warranties apply simultaneously to the indicated capacity of the plant and are to be calculated for full period of 140 hours during which properly prepared raw material, steam, water and electricity will be supplied under abovesaid conditions and without any interruption.

Once the warranties are so demonstrated, ipso facto, all responsibilities on the part of Vendors shall be deemed to have been fulfilled and no further claims of whatsoever nature or description shall be entertained.

UTILITIES:

STEAM CONSUMPTION:
Extraction: Less than 400 Kg/ton (880 lbs/ton) of entering material Dry steam at 6 atm abs (85 Psig) provided correct insulation of piping and apparatus following our prescriptions.

WATER IN CIRCULATION: 55,000 gallons/hour at 30°C.

POWER CONSUMPTION: about 40 Kwh/ton. MAN POWER: ONE MAN.

EXHIBIT 'H'

SERVOTECH ENGINEERS PRIVATE LIMITED
P.B.6073, Colaba, Bombay-5.BR
Cables: "SERVOTECH" Phone: 212896

SOYBEAN PROCESSING PLANT -- PROPOSALS

		Rs	Rs
I.	"250/500 SPECIAL" Initial capacity 250 Tonnes/24 hours but with built-in capacity for 500 Tonnes/24 hours in some sections.		
	1. PREPARATORY SECTION with imported Forsberg Cleaning Equipment for edible products manufacture, Ross Hydraulic Flakers 2 Nos. and SERVOTECH Krakers 2 Nos. two pairs, Conditioner, Feed Conveyor from Preparatory section to Solvent Extraction Plant designed for 500 Tonnes capacity, Hulls separating, grinding and toasting equipment, mechanical transport equipment designed for 500 Tonnes in 24 hours capacity, all the supporting steel structures, electric control panel and wiring.	1,462,030	
	2. EXTRACTION SECTION with imported CROWN Extractor 600 Tonnes/ 24 hours capacity and SERVOTECH DEXANIZER-TOASTER, stainless steel Vaposcrubber, Condenser and connecting piping.	1,764,970	
	3. SERVOTECH Miscella Evaporation section, Trifun system, Solvab system, open air steel building with columns, beams, platforms, railings, staircases, trusses, purlins, etc. designed for 500 Tonnes capacity plant, Bulk storage tanks for hexane, Emergency water storage tank, Day tank for oil in the plant, electric control panel and EP electricals.	775,000	
	4. FINISHING SECTION with Meal conveyor from Dexanizer-Toaster designed for 500 Tonnes capacity, Meal Cooler, Grinding and Separating equipment, mechanical transport equipment designed		

	Rs	Rs
for 500 Tonnes capacity, imported Howe Richardson Automatic Bagging machine and Bag closing machine.	560,800	
	---------	4,562,000
Additional equipment for stepping up the capacity of the plant to 500 T/24 hours.		
a) Preparatory section	650,000	
b) Extraction section	650,000	
c) Finishing & Grinding Section	300,000	
	---------	1,600,000

TOTAL COST for 500 Tonnes/24 hrs. plant ..		6,162,800
		=========

NOTE: An import licence for a value of US $190,000 would be required for the import of machinery.
Import licence value for expansion would be US $36,079.

II. "250 SPECIAL"

Same as above, but without provision for expansion to 500 Tonnes capacity.	4,012,000
	=========

NOTE: An import licence for a value of US$148,000 would be required for the import of machinery.

III. SERVOTECH 250 Tonnes/24 hours plant, indigenous.	3,385,800
	=========

NOTE: Import licence for 7.5% of value of plant is required for importing critical components not available in India.

IV. SERVOTECH 100 Tonnes/24 hours plant, indigenous.	1,900,000
	=========

NOTE: Import licence for 5% of value of plant is required for importing critical components not available in India.

All prices indicated above are net, ex works Bombay. In all cases the supply of material for the processing plant is complete. Only foundations and civil works, erection, installation and insulation are not covered. The steel structures for the Extraction, Preparation and Finishing sections, Bulk storage tanks for Hexane, Emergency Water Storage Tank, Day tank for oil in the plant, complete electrical equipment and wiring not only in the Extraction section but Preparatory and Finishing sections as well are included in the supply.

SPECIFICATION FOR "250/500 SPECIAL" SOYBEAN PROCESSING PLANT.

Sl.No.	Description	Quantity
	I. PREPARATORY SECTION.	
1.	ELECTRO MAGNETIC SEPARATOR complete with Rectifier unit, TEFC motor and drive	1
2.	FORSBERG SCREEN AIRE UNIT with woven wire screens, operating at high speed, with positive drive eccentrics, with facility to adjust screening separation and air separation independently of each other, circular movement of screen creates continual turn of the product so that there is always total contact of the product and screen, complete with 3/4 HP drive and ventilator.	1
3.	FORSBERG VACUUM DESTONER in all steel construction with built-in stratified floatation separation of purities, complete with 3/4 HP drive and 15 HP ventilator.	1
4.	FORSBERG VACUUM GRAVITY SEPARATORS in all metal construction, with rubber-bushing suspension and deck adjustment system, with enlarged non-splitting return legs, with improved counter-balance drive and calibrated markings on all controls, designed for dust-free operation with 10 HP motor.	2
5.	SERVOTECH KRACKERS in all steel frame, two pairs chilled cast iron fluted rolls moving on heavy roller bearings, with gap adjusting device, feed roller and v-belt drive with two TEFC motors, gear boxes and drives.	2
6.	FORSBERG PNEUMATIC SCALPER for separation of hulls from cracked beans, complete with 5 HP ventilator.	1
7.	SERVOTECH TEMPOCONDITIONER in five stages with double bottoms, with REVINJECTION device, level regulating device, motor, gear box and drive.	1

8. ROSS 20x42 HYDRAULIC FLAKING MILLS 2
with heavy duty V-belt differential drive and guard, vibratory feeder, split main housing for easy roll removal, hydraulic power unit with pump, motor and accumulators, hydraulic control and fittings, Turn Tuff rolls ground, with double row of spherical roller bearings, with 100 HP TEFC motor and drive.

9. SERVOTECH FEED CONVEYOR 1
with pressed steel casing, special alloy steel chain and guide straps, with tensioning arrangement and driving arrangement with gear box and EP motor.

10. GRINDER 1
for hulls with motor and drive.

11. TOASTER 1
for hulls with TEFC motor and drive.

12. All the necessary mechanical transport equipment 1 Lot
with elevators & screw conveyors designed for 600 Tonnes/24 hours capacity, complete with gear boxes, TEFC motors and drive.

II. EXTRACTION SECTION

1. RATOSEAL 1
feed valve for maintaining a pre-determined rate of feed to the Extractor and providing a vapour-seal, complete with chain drive (off the Feed conveyor).

2. FEEDOBIN 1
mounted on the Extractor for holding feed stock, complete with light and sight glasses.

3. CROWN EXTRACTOR - 600 Tonnes/24 hrs. 1
percolation type, approximately 6 ft. wide, complete with vari speed drive, with an Accuracy nuclear sensor for proper flake level control, completely pre-assembled before despatch.

4. DISCHARGBIN 1
for receiving the extracted material discharged by the Extractor.

5.	**MISCIRCULATING PUMPS** all-iron construction, suitably grouped and driven by EP motors for fresh solvent feed to the Extractor and miscella circulation.	7
6.	**SERVOTITE CONVEYOR** solvent-tight construction with SERVOSEAL for transporting the extracted material from the Dischargbin to the Dexaniser-Toaster, complete with EP motor and drive.	1
7.	**RATOSEAL** feed valve, for proper regulation of feed and provision of vapour seal, complete with chain drive (off SERVOTITE CONVEYOR).	1
8.	**DEXANIZER-TOASTER** special vertically mounted, multi-pan construction with double bottoms, steam heating arrangement with open steam diffuser device, with SERVOSEAL closure, with heavy agitator assembly, gear box and drive, with special LEVELLUGATCH devices in each pan, feed discharge correlating arrangement, etc.	1
9.	**PLUGOSEAL** discharge conveyor complete with drive.	1
10.	**VAPOSCRUBBER** in stainless steel construction, for scrubbing vapours free of suspended dust.	1
11.	**DEXCONDENSOR** multi-pass cartridge type shell and tube condensor with mild steel shell and brass/cupro nickel tubes.	1
12.	**MIXO COOLER** for final cooling of vent before entering Solvab Unit.	1

III. MIVAP SYSTEM, TRIFUN SYSTEM AND SOLVAB SYSTEM.

1.	**PRIMEVAPORATOR** mild steel body, tubulature in mild steel, specially designed for rapid primary evaporation of misoella using low pressure steam.	1

2. PRIMEFLASHER — 1
mild steel construction for cyclone-separation of primary flash vapours, with light and sight glass fittings, complete with entrainment separator.

3. SECONEVAPORATOR — 1
similar in construction to PRIMEVAPORATOR for secondary concentration of oil.

4. SECONFLASHER — 1
similar in construction to PRIMAFLASHER for separation of secondary flash vapours.

5. FATFINISHER — 1
specially designed for super stripping of residual solvent in the finishing oil, operating under high vacuum, mild steel body, internals in mild steel, complete with light and sight glasses.

6. MULTUBE CONDENSOR — 1
multi-purpose, multipass cartridge type shell and tube condensor, body in mild steel, tubulature in brass/cupro nickel.

7. SECONDENSOR — 1
secondary condensor, same as above.

8. MIVACUATOR — 1 set
triple evacuators for maintaining the desired multi-level vacuum on the evaporation system.

9. MITRANPUMPS — 4
all-iron centrifugal pumps, sutably grouped for drive by EP motor/s, complete with base frame.

10. MIRESERVOIR — 1
mild steel construction, for reception of miscella from the Extraction section and feed to the Evaporation section.

11. AQUEXSEPARATOR — 1
special unit for effective aqua-hexane separation.

12. HEXERVOIR, plant reservoir for hexane. — 1

13. EFFLASHER — 1
thermostatically controlled device for flash-recovery of solvent in process effluent.

14. MIRATOR 1
direct-indicating device for control of rate of evaporation.

15. TEMPEGULATORS 2
for thermostatic control at strategic places in the process.

16. TIFEXCHANGER 1
multi-pass cartridge type, specially designed for most efficient heat exchange between the Desolventizer gases and the miscella, shell in mild steel, welded construction and tubulature in special alloy.

17. TIFLASHER 1
mild steel welded construction, for centrifugal flashing of vapour from miscella, with special liquo-baffles, with light and sight glass fittings.

18. TIFCIRPUMP 1
high throughput all-iron circulation pump, complete with EP motor and drive, for circulation of miscella through the system.

19. SOLABSORBER 1
horizontal model, shell of mild steel construction, with water cooling device to dissipate exothermic heat, shaft in steel, mounted on special bearings, vapour-tighteness ensured with SERVOSEAL, internals in stainless steel, complete with EP motor and drive.

20. SOLEVAPORATOR 1
vertical model, in mild steel construction, with steam heating and stripping devices, specially designed for stripping the absorbing medium of absorbed solvent in two stages, complete with light and sight glasses.

21. SOLCOOLER 1
in mild steel construction, designed for efficient heat transfer between the hot absorbing medium and cooling water, reducing the temperature of the former to the desired level appropriate for optimum performance in the SOLABSORBER.

22. SOLCIRPUMP 1
for circulating the absorbing medium in the unit with specially designed driving mechanism.

23.	SOLERATOR direct-indicating device for control of rate of circulation of the absorbing medium in the unit.	1

IV. FINISHING SECTION

1.	MEAL CONVEYOR for transporting the meal from the Extraction section, in M.S. pressed casing, chain and wearing straps in wear resisting steel, tensioning device, complete with EP motor and drive.	1
2.	MEAL COOLER clad with louvres on all sides, with a number of cooling trays one over the other, with an agitator assembly, complete with motor and drive.	1
3.	LOW SPEED GRINDER with motor and drive.	1
4.	HIGH SPEED GRINDER with motor and drive.	1
5.	SHAKER-SEPARATOR with motor and drive.	1
6.	All the necessary mechanical transport equipment designed for 500 Tonnes/24 hours capacity, complete with gear boxes, TEFC motors and drive.	1 Lot
7.	HOWE RICHARDSON automatic Bagging machine and bag closing machine.	1

ADDITIONAL SUPPLIES

1. STEAM MAIN inside the plant complete with water separator, main stop valve, reducing valve, safety valve, pressure gauges for distribution of steam inside the precincts of the plant.

2. CONDENSATE COLLECTION PIPING inside the precincts of the plant.

3. WATER MAIN inside the plant complete with stop valve, pressure gauge, etc. for distribution water inside the precincts of the plant.

4. Effluent piping inside the precints of the plant.

5. All the necessary steam valves for the steam circuit
All the necessary steam traps for the condensate circuit
All the necessary Audco valves for miscella/solvent circuit
All the necessary heavy guage pipes for piping
All the necessary BSS flanges, bolts, & nuts and gaskets for piping
All the necessary VISIFLO devices
All the necessary Thermometers, Pressure/Compound/Vacuum gauges and Manometers.

6. ELECTRICALS as per preferred arrangement.
EP motors for Pumps
EP push buttons for motors
EP light fittings for apparatus lighting
EP cables for wiring up all electrical items in the Extraction Plant from the control panel
Cable trays for EP wiring in the Extraction Plant.

7. ELECTRIC CONTROL PANELS
with sequencing, interlocking and other safety devices for controlling the operations in the plant and for the Preparatory and Finishing sections.

8. AUDIO VISUAL ALARM SYSTEM for drawing operator's atten tion in the event of abnormal operation.

9. MOTORISED STEAM VALVE to cut off steam supply to the Plant in the event of power failure.

10. PRESSIOSTAT to stop the Dexanizer unit in the event of too low steam pressure.

11. THERMOSTAT SAFEGUARD against inadequate water supply.

12. MASTER SWITCHES for emergency stopping of Extraction Plant.

13. SIGNALLING DEVICE between Extraction Plant & Preparatory Section.

14. EMERGENCY WATER STORAGE TANK for the plant.

15. BULK STORAGE TANKS FOR storage of Hexane for the Plant.

16. DAY TANK for oil in the plant.

17. Open air steel building for solvent extraction Plant with columns, beams, platforms, staircases, railings, etc. as per preferred arrangement.

18. Supporting structures with columns, beams, platforms, staircases, railings, etc. as per preferred arrangement for the Preparatory and Finishing sections.

19. SPECIAL DOUBLE GLASS WINDOW to be fixed by customer in his civil works.

20. PRESSURISING FAN
for maintaining the control cabin under pressure to prevent ingress of solvent complete with elevated air entry to conform to safety regulations.

21. WARNING BOARDS: 'RESTRICTED AREA'
'CONTROLLED AREA'
'NO ADMISSION'
'NO SMOKING'

22. One set of sparkless tools, as per standard practice.

NOTE: We reserve the right to alter or amend the specifications in the light of later developments and exigencies of the situation subject to the condition that the overall performance is not affected.

WARRANTEE

1.	CAPACITY:	250 Tonnes of Soybeans of 20% oil content
2.	DEOILING:	Below 1% by weight, analysis to be conducted by standard AOCS method using the same solvent as is used in the process.
3.	SOLVENT CONSUMPTION:	10 litres/tonne of entering material, subject to (a) the required quantity of cooling water at 30°C being made available (b) the plant being run uninterruptedly, and (c) normal Hexane being used as solvent with boiling range 67/69°C, non volatiles content loss than 0/001 gm/100 ml. and aromatics content less than 1.0%.

UTILITIES

1.	STEAM:	350 Kg/tonne, dry saturated steam at 150 Psig.
2.	POWER:	40 KWH/tonne, 400/440 volts, 3 phase, 50 Cycles A.C.
3.	WATER:	200 Cu.Mt. per hour in circulation, can be cooled and recycled.
4.	OPERATING LABOUR:	One operator and two assistants per shift.

250T/24H PLANT

EXHIBIT 'I' - DETAILS OF FINANCE FORECAST

			Rs.	Rs.
A.		STEAM RAISING PLANT		
	1.	Fully Automatic Packaged Boiler (Westerworks) 5500 Kg. per hour evaporation, 150 Psig, complete with accessories.	222,800	
	2.	Fuel oil tanks 2 x 5000 glns. with pumps and piping.	35,000	
	3.	Chimney	30,000	
	4.	Feed & Condensate Water Tanks.	20,000	
	5.	Water Softening Plant.	25,000	
	6.	Steam Distribution Main.	30,000	
	7.	Condensate Return.	10,000	372,800
B.		WATER COOLING & PUMPING INSTALLATION:		
	1.	Cooling Tower 50,000 gallons per hour capacity.	50,000	
	2.	Water circulating pumps 3 Nos. 50,000 gallons per hour.	30,000	
	3.	Valves, pipes, etc.	30,000	
	4.	Panel, wiring.	15,000	125,000
C.		ELECTRICAL INSTALLATION:		
	1.	Transformers, 11,000/440 Volts. 3 Phase, 50 Cycles, A.C. 750 KVA - 2 Nos.	80,000	
	2.	HT Reception, Cabling and Circuit Breaker.	40,000	
	3.	LT Distribution Panel	50,000	
		c/o	170,000	

EXHIBIT 'I'(Contd.)

		Rs.	Rs.
C.	ELECTRICAL INSTALLATION (CONT'D		
	B/F	170,000	
	4. Cabling	50,000	
	5. Lighting including yard lighting	30,000	
	6. Earthing	20,000	
	7. Power Factor Capacitors	50,000	
			320,000
D.	BULK STORAGE INSTALLATION:		
	1. Oil Storage Tanks 5 x 100 Tons capacity @ Rs.40,000 each.	200,000	
	2. Pumps and Piping	15,000	
			215,000
E.	SUNDRY EQUIPMENT:		
	1. Laboratory Equipment	30,000	
	2. Fire Fighting Equipment	40,000	
	3. Workshop Equipment	50,000	
	4. Tools, Tackles & Implements	40,000	
	5. Furnitures & Fixtures	20,000	
	6. Office Equipment	20,000	
			200,000
F.	SILO STORAGE & MEAL HANDLING EQUIPMENT:		
	1. Wagon Tippler - Elecon, End-Rocker type	1,200,000	
	2. Forklift Trucks (2) Portable belt conveyor for loading bags in wagons etc.	200,000	
	3. Ventilation Equipment for Silos	145,825	
	4. Pneumatic Scalper, capacity 2000 Bushels per hour	21,750	
	C/O	1,567,575	

EXHIBIT 'I' (Contd.)

			Rs.	Rs.
F.	SILO STORAGE & MEAL HANDLING EQUIPMENT (CONT'D)			
		B/F	1,567,575	
	5.	Clipper Continuous Drier, capacity 1500 bushels per hour, Moisture 13 to 9½%	452,425	
	6.	Mechanical Transport Equipment, capacity 50 tonnes per hour.	700,000	
	7.	Electricals.	80,000	
				2,800,000
G.	RAILWAY SIDING & SHUNTER:			
	1.	Railway Siding inside the Factory.	800,000	
	2.	Tata Diesel Wagon Shunter	372,000	
	3.	Sundries	28,000	
				1,200,000
H.	WEIGHING EQUIPMENT:			
	1.	Wagon Weigh Bridge 100 Ton capacity with weight printing mechanism.	212,290	
	2.	Truck Weigh Bridge 40 Ton capacity.	106,917	
	3.	Dormat Weighing Scale, 5 Ton capacity for Oil weighment.	25,860	
	4.	Weigh Scale for Stores 500 Kg.	9,776	
	5.	Sundry expenses.	20,157	
				373,000
I.	SILOS - 25,000 Tons storage capacity in RCC @ Rs.150/- per tonne.			3,750,000
J.	LAND & BUILDING			2,500,000

EXHIBIT 'I' (CONTD.) ESTIMATE OF COST

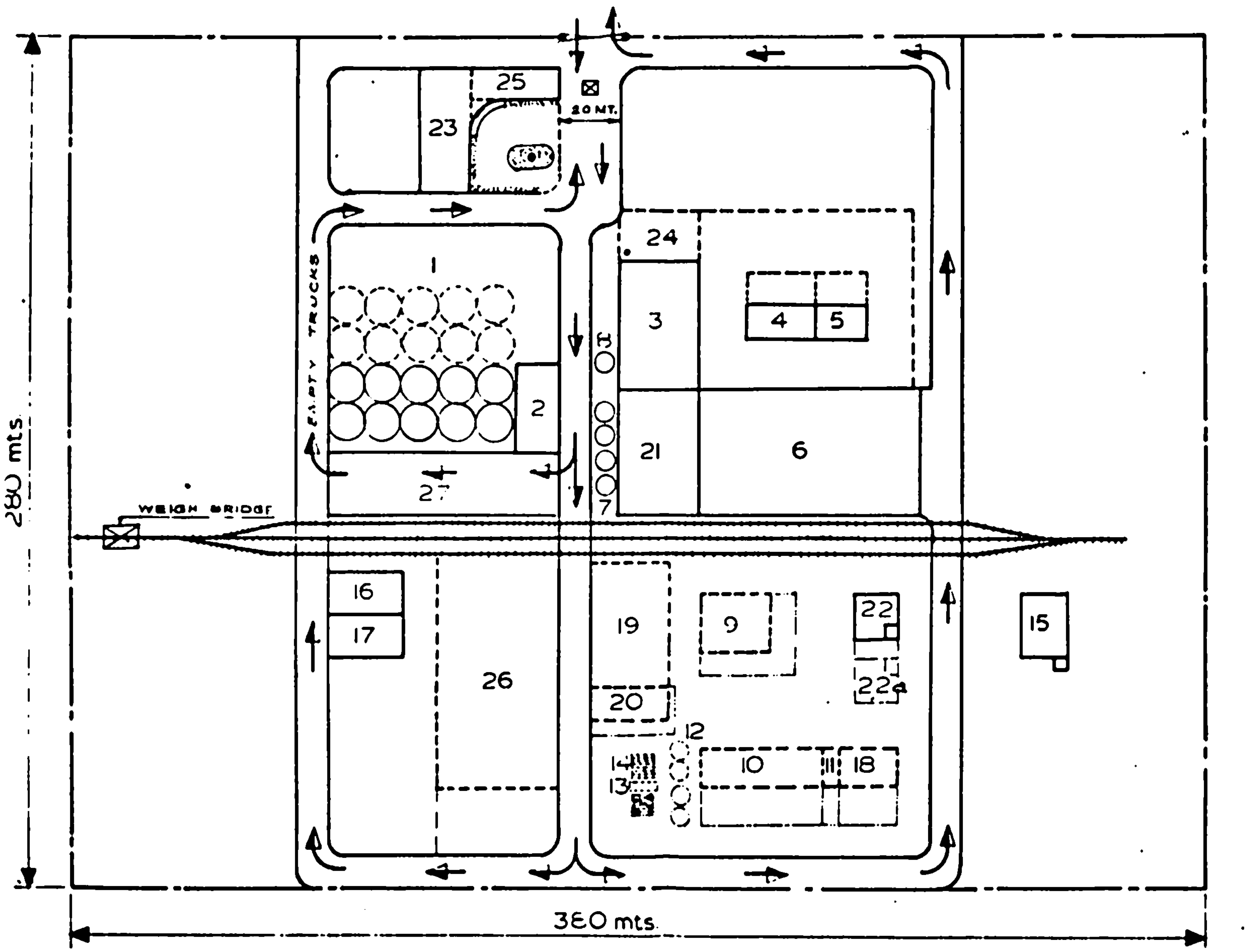
LAND & FACTORY BUILDING - DRAWING NO.LOT:FY:79

		Position in the Drawing.	Area in Sq.Meters.	Cost. Rs.	Rs.
1.	Silo Head Works.	2	435	130,500	
2.	Unloading Warehouse	27	1550	232,500	
3.	Preparatory and Finishing Section	3	963	192,600	
4.	Oil Mill Building	21	963	192,600	
5.	Civil Works for Solvent Extraction Plant.	4	200	50,000	
6.	Meal Warehouse	6	3034	606,800	
7.	Boiler House	15	300	60,000	
8.	General Stores	16	324	64,800	
9.	Workshop	17	324	64,800	
10.	Cooling Pond	22	196	24,500	
11.	Office Building	23	500	100,000	
12.	Equipment Foundations			113,400	
				-------	1,832,500
13.	Land 26 Acres @ Rs.5000/- per acre.			130,000	
14.	Development, levelling, etc.			70,000	
15.	Compound Wall, etc.			92,500	
16.	Roads inside Factory.			250,000	
17.	Wells, Water Column.			100,000	
18.	Storm Sewer.			25,000	
				-------	667,500
			TOTAL :		2,500,000

EXHIBIT 'J'

LIST OF EQUIPMENT RECOMMENDED FOR IMPORT.

1.	FORSBERG 4-Stage Cleaning Equipment	..	$ 13,970
2.	ROSS Hydraulic Flaker 2 Nos.	..	35,610
3.	CROWN Extractor 600 Tons/24 Hours	..	119,000
4.	HOWE Bagging & Sewing Machine	..	4,309
5.	Continuous Weighing Machine for weighing beans issued to process (firm Quote not yet received - approx.)	..	3,807
6.	FORSBERG Pneumatic Scalper 2000 Bushels per hour for Silo Section.	..	1,354
7.	CLIPPER Bean Drier 1500 Bushels per hour	..	41,950
			$ 220,000
8.	Add Packing, Insurance, Ocean Freight	..	20,000
9.	Total approximate c.i.f.		$ 240,000
10.	Total c.i.f.	..	Rs.1,800,000



280 mts.
360 mts.
WEIGH BRIDGE
EMPTY TRUCKS
20 MT.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
22a
23
24
25
26
27

TYPICAL LAYOUT - FACTORY SITE PLAN.

Pos no	Description	Dimensions (mts)
27	BAG UNLOADING.	77.5 x 21.0
26	SEED GODOWN.	74.0 x 41.0
25	WEIGH BRIDGE OFFICE.	
24	FILLING POINT.	
23	MAIN OFFICE.	
22a	COOLING POND & PUMP HOUSE. FOR BAROMETRIC CONDENSER WATER.	14.0 x 14.0
22	COOLING POND & PUMP HOUSE. FOR CONDENSER WATER.	14.0 x 14.0
21	OIL MILL.	41.0 x 27.5
20	COOLING ROOM & PACKING ROOM.	27.0 x 10.0
19	VANASPATI GODOWN.	41.0 x 27.5
18	ELECTRICAL SUB-STATION.	20.0 x 11.35
17	WORKSHOP	24.0 x 19.5
16	GENERAL STORES.	24.0 x 19.5
15	BOILER HOUSE.	20.0 x 15.0
14	HIGH PRESSURE CYLINDERS.	10.0 x 10.0
13	HYDROGEN COMPRESSOR ROOM.	10.0 x 8.0
12	GAS HOLDERS.	ø 6.0
11	RECTIFIER ROOM	11.35 x 5.0
10	CELL ROOM	39.95 x 11.35
9	VANASPATI PLANT.	28.0 x 19.5
8	DAY BIN FOR SOYABEANS.	ø 6.0
7	OIL STORAGE.	ø 6.0
6	MEAL STORAGE.	74.0 x 41.0
5	CONCENTRATE, ISOLATE (PROTEIN) PLANT.	15.0 x 10.0
4	SOLVENT EXTRACTION PLANT.	20.0 x 10.0
3	PREPARATORY & FINISHING SECTION.	85.0 x 27.5
2	HEAD WORKS.	22.0 x 15.0
1	SOYABEAN STORAGE.	62.5 x 29.0

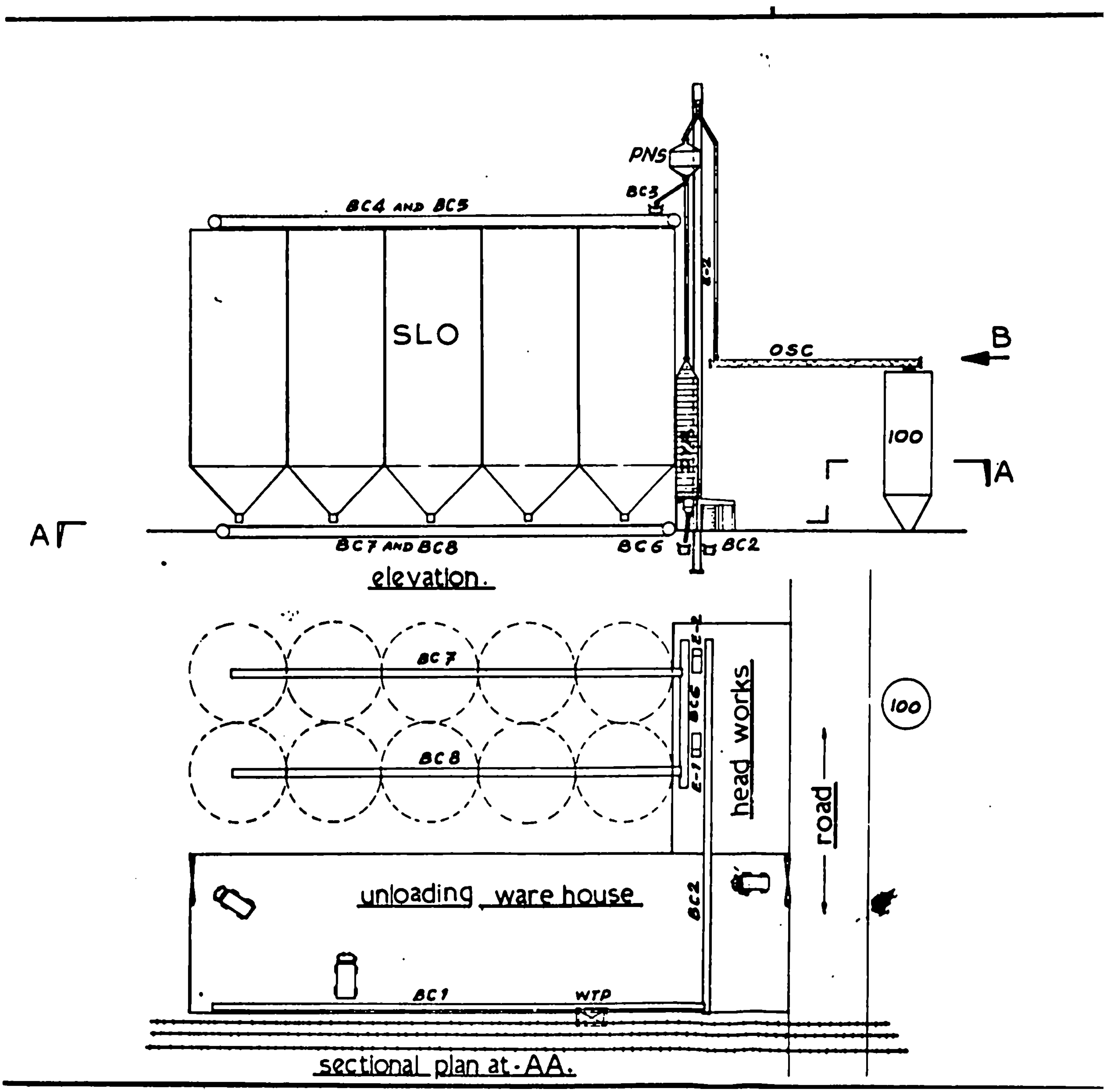
ALL ROADS ARE 10.0 m WIDE UNLESS & OTHERWISE STATED.

TOTAL AREA = 26 ACRES.

SERVOTECH

POST BOX 6075
BOMBAY 9 (BR)

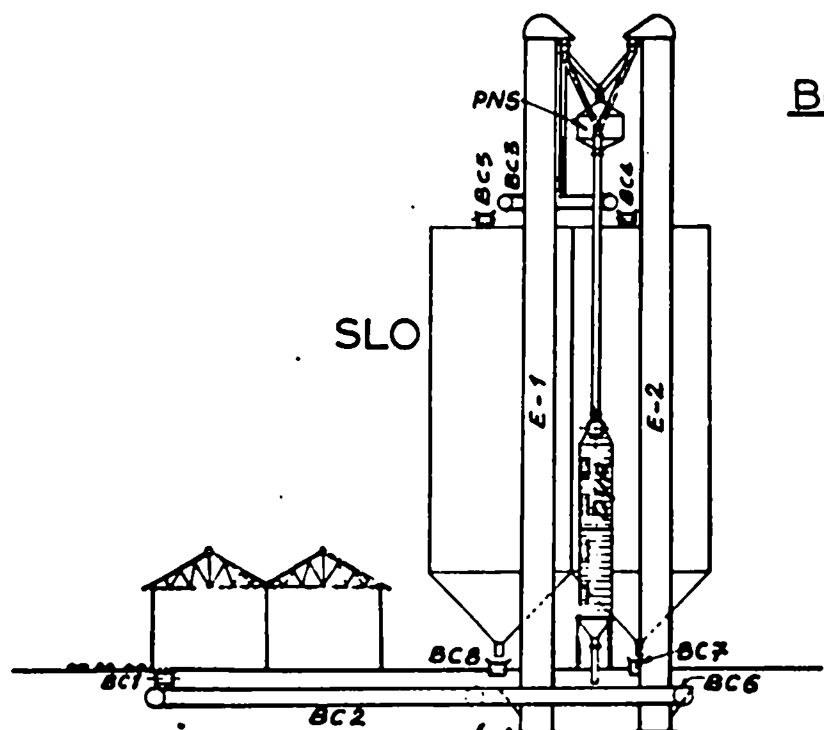
DRG. NO. LOT: FY 79



PNS
BC3
BC4 AND BC5
SLO
E-2
OSC
B
100
A
A
BC7 AND BC8
BC6
BC2
elevation.
BC7
BC8
E-2
BC6
E-1
head works
100
road
unloading ware house
BC2
BC1
WTP
sectional plan at AA.

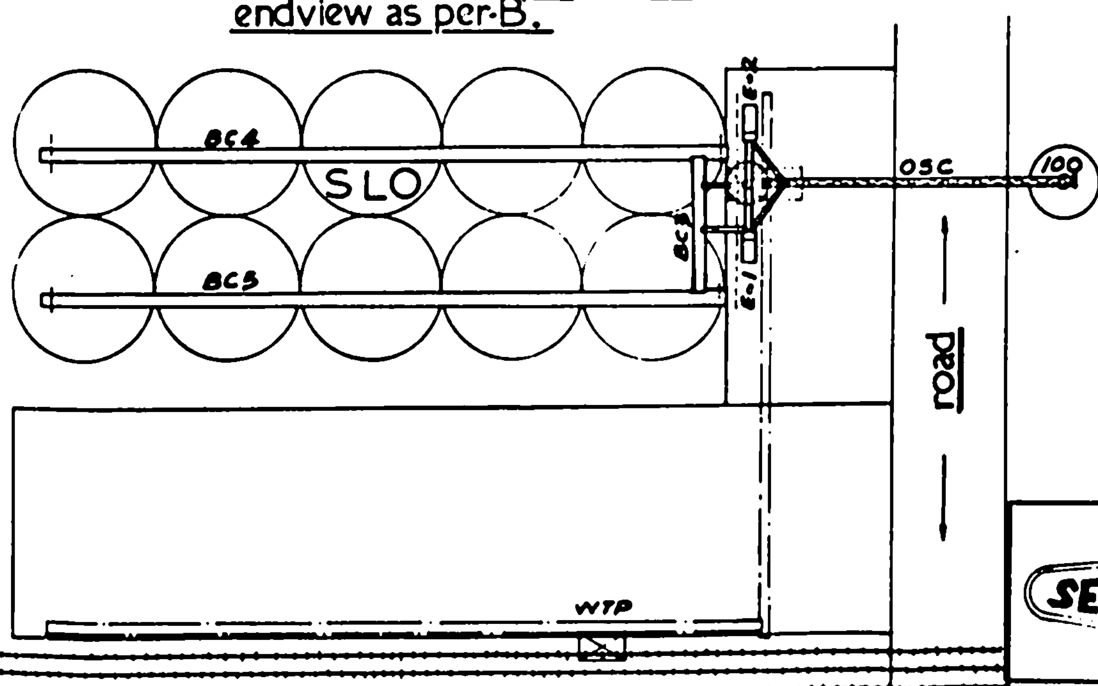
General Arrangement

Bean Reception, Handling and Storage



endview as per 'B'.

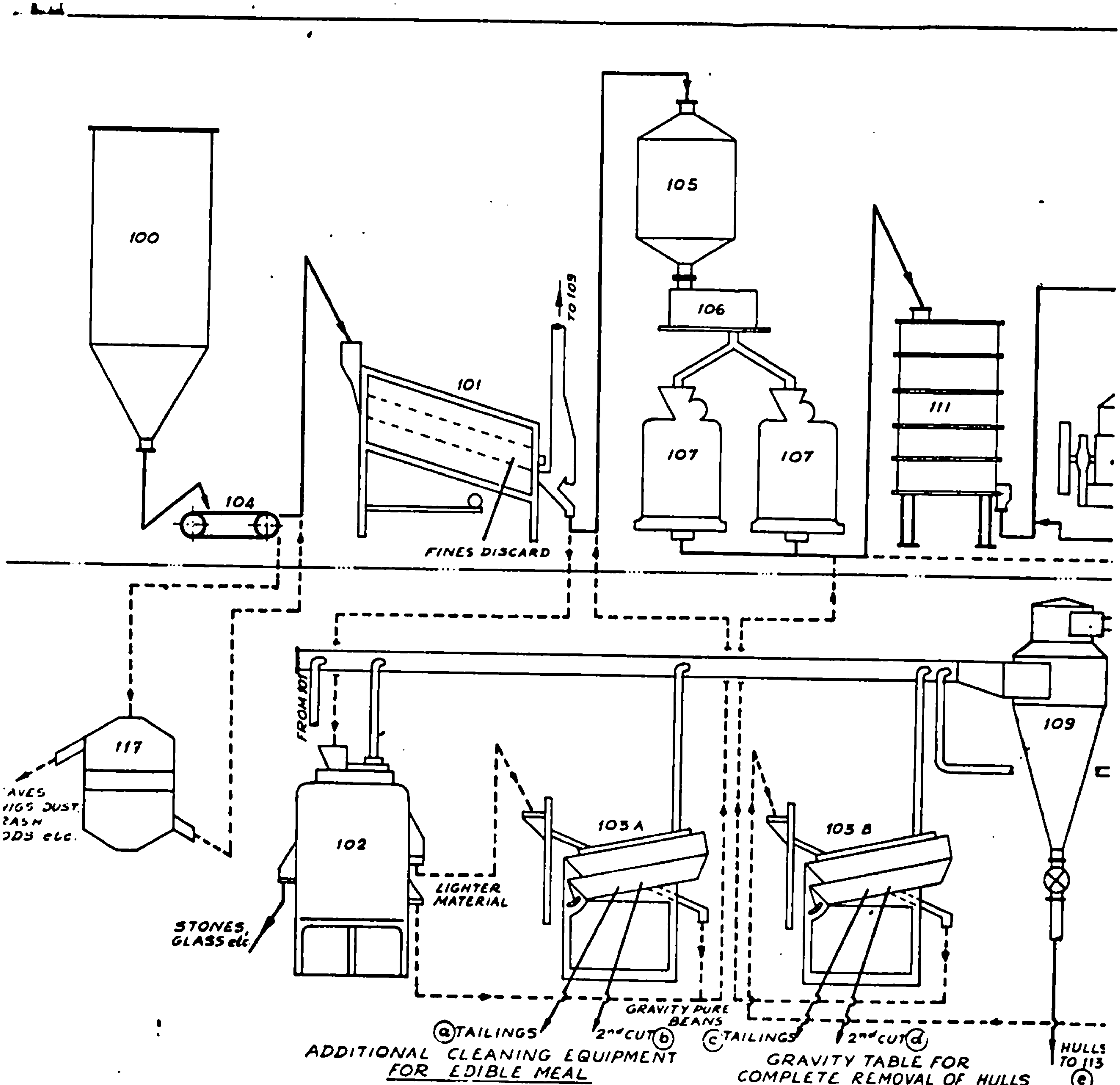
POS.NO.	DESCRIPTION
WTP	WAGON TIPPLER
SLO	SILO
BC	BELT CONVEYOR
E	ELEVATOR
PNS	PNEUMATIC SCALPER
DYR	DRYER
OSC	OVERHEAD SCREW CONVEYOR
100	DAY BIN



top view.

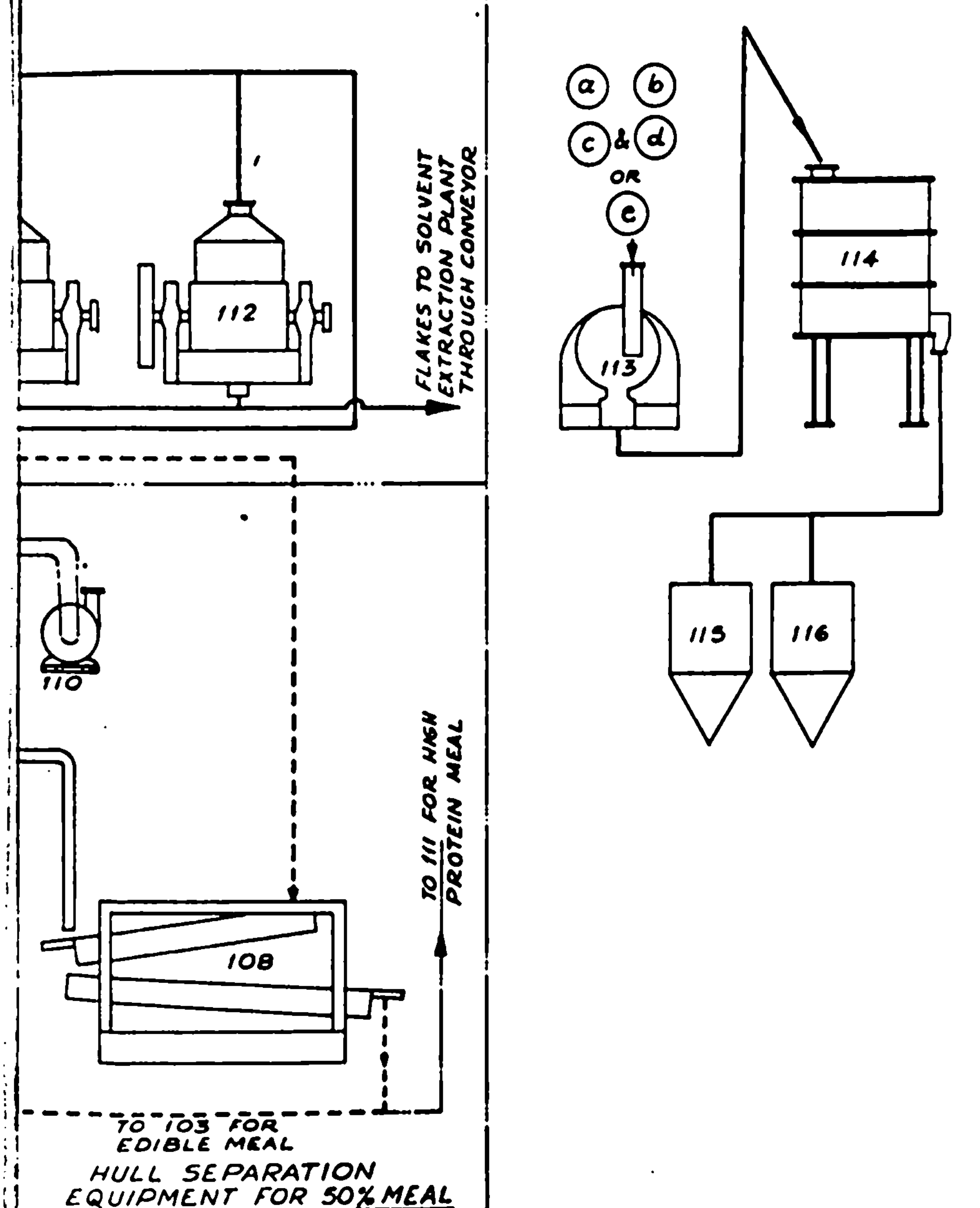
SERVOTECH
POST BOX 6078
BOMBAY-8 (BR)

DRG. NO. LOT. SSS: 116.



EQUIPMENT FOR EDIBLE MEAL PREPARATION

FLOWSHEET FOR CONTINUOUS SOYBEAN PREPARATION

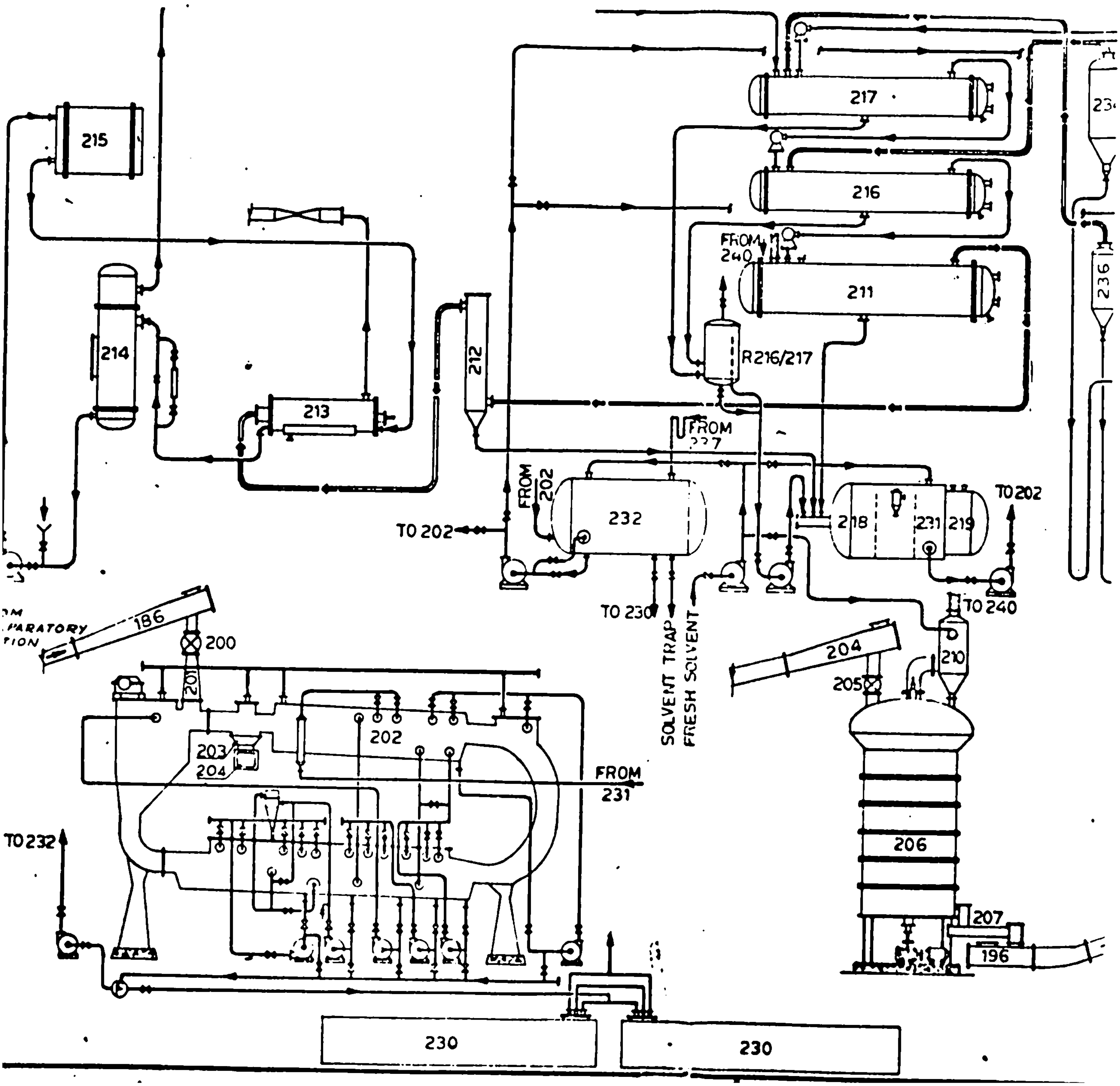


117	SCALPER
116	GROUND HULLS STORAGE BIN
115	GROUND DOCKAGE STORAGE BIN
114	TOASTER
113	GRINDER
112	FLAKER
111	CONDITIONER
110	BLOWER
109	CYCLONE
108	SHAKER SEPARATOR
107	CRACKER
106	SCALE
105	SURGE BIN
104	MAGNETIC DRUM
103	GRAVITY TABLE
102	DESTONER
101	SCREEN
100	DAY BIN

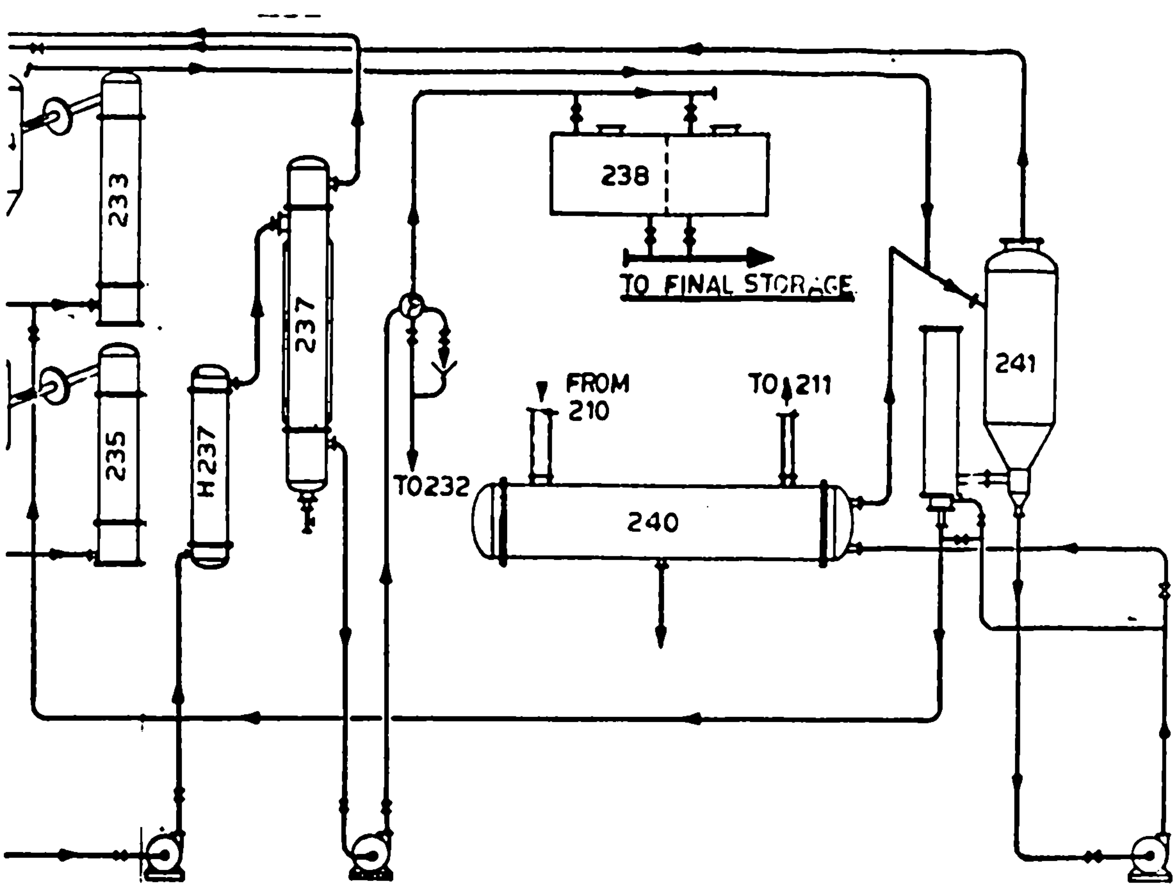
SERVOTECH

POST BOX: 6075
BOMBAY~5 (BR)

DRG. NO. FLS:PRP 75



215
214
213
212
217
216
211
R216/217
FROM 240
FROM 227
FROM 202
232
TO 202
TO 230
SOLVENT TRAP
FRESH SOLVENT
218
231
219
TO 202
TO 240
186
200
201
PARATORY
TION
202
203
204
FROM 231
TO 232
204
205
210
206
207
196
230
230
236



FLOWSHEET FOR CONTINUOUS SOLVENT EXTRACTION PLAN

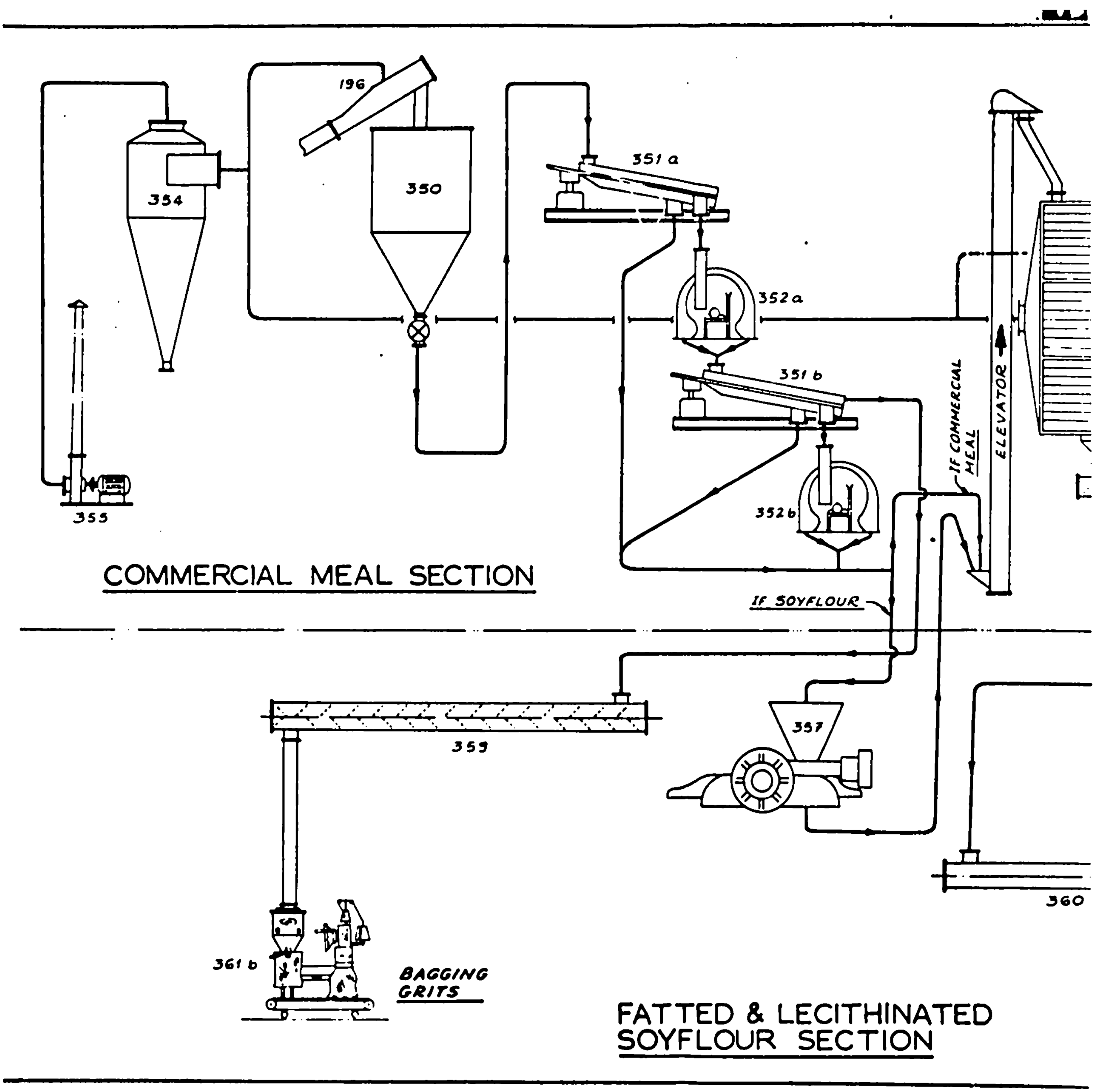
200	ROTARY VALVE
201	FEED BIN
202	EXTRACTOR
203	DISCHARGE BIN
204	SOLVENT TIGHT CONVEYOR
205	ROTARY VALVE
206	DESOLVENTISER TOASTER
207	CONVEYOR
210	SCRUBBER
211	CONDENSER
212	CONTACT CONDENSER
213	SOLVENT ABSORBER
214	SOLVENT EVAPORATOR
215	SOLVENT COOLER
216	CONDENSER
217	CONDENSER
[illegible]	RECEIVE[illegible]
218	WATER SOLVENT SEPARAT[illegible]
219	EFFLUENT FLASHER
230	UNDERGROUND SOLVENT STORAGE TANK
231	SOLVENT RESERVOIR
232	MISCELLA RESERVOIR
233	PRIMARY EVAPORATOR
234	PRIMARY FLASHER
235	SECONDARY EVAPORATOR
236	SECONDARY FLASHER
H 237	MISELLA HEATER
237	FINAL STRIPPER
238	FINISHED OIL STORAGE TANK
240	ECONOMISER
241	FLASHER

ACKNOWLEDGEMENT :- EXTRACTOR COURTESY CROW IRON WORKS CO. U.S

TO FINISHING SECTION

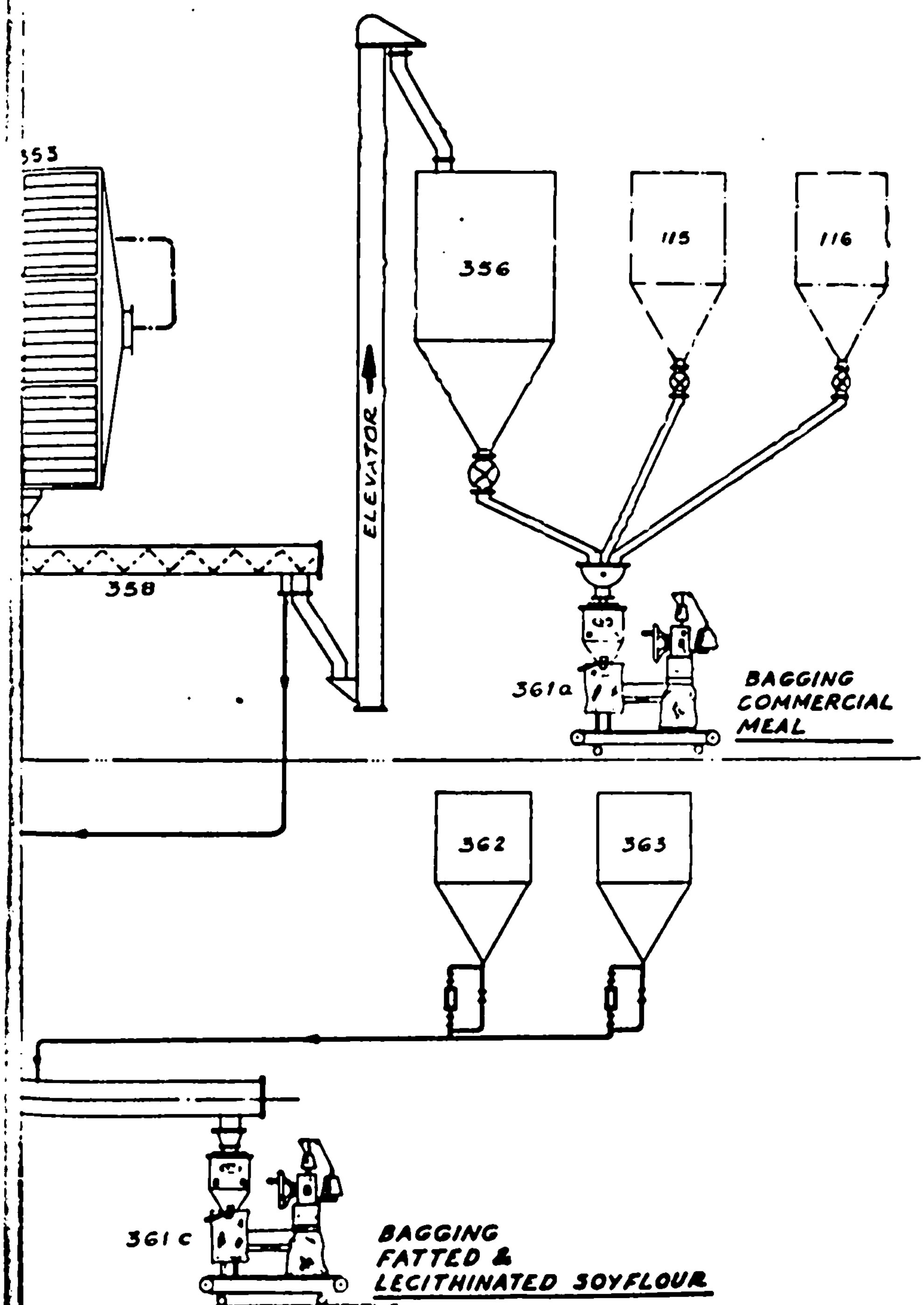
SERVOTECH
POST BOX 6073
BOMBAY 5 BR

DRG. NO.
FLS:SEP 76



196
354
350
351 a
352 a
351 b
352 b
355
IF COMMERCIAL MEAL
ELEVATOR
COMMERCIAL MEAL SECTION
IF SOYFLOUR
359
357
360
361 b
BAGGING GRITS
FATTED & LECITHINATED SOYFLOUR SECTION

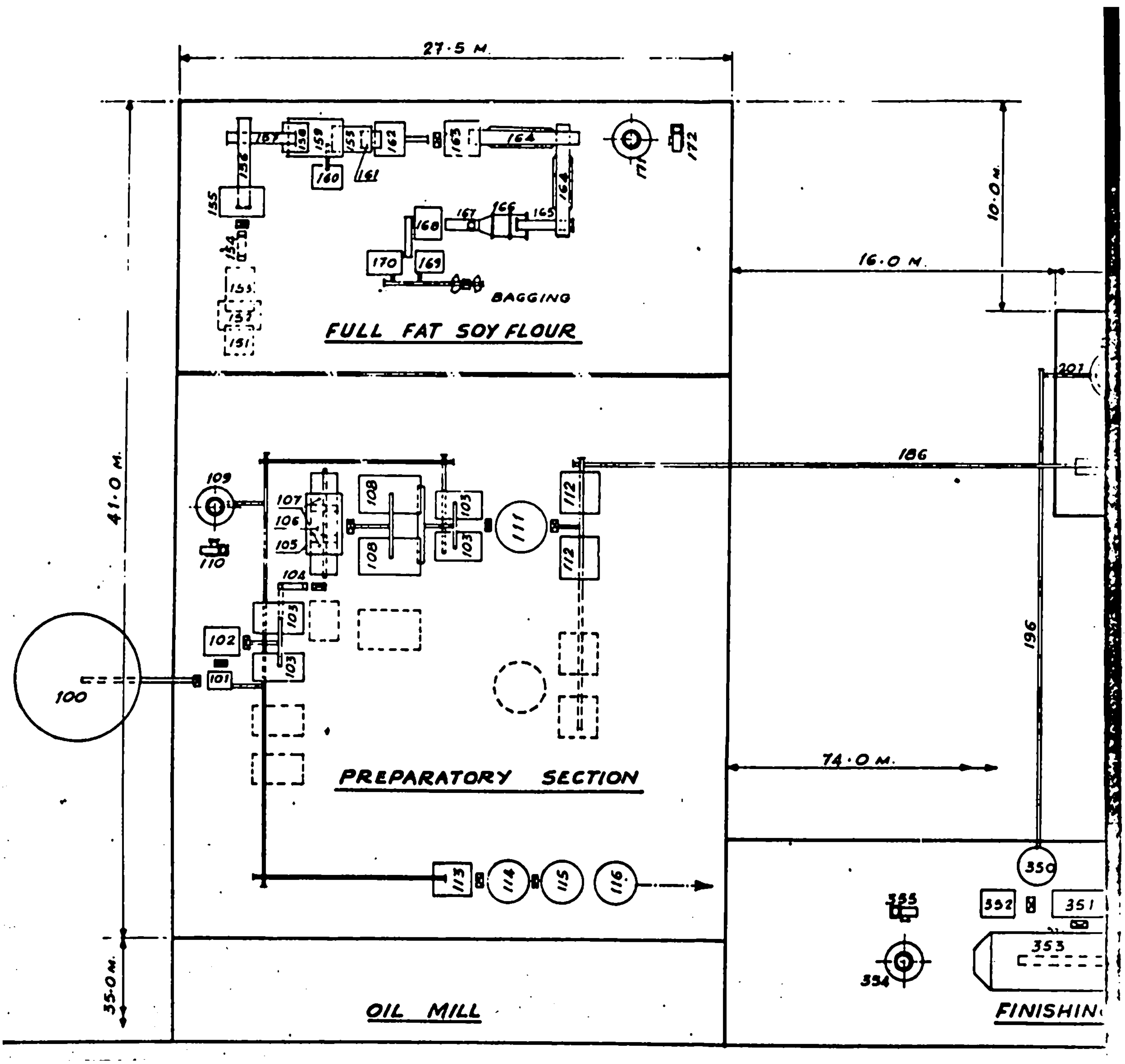
FLOWSHEET OF MEAL FINISHING SECTION



116	GROUND HULLS STORAGE BIN
115	GROUND DOCKAGE STORAGE BIN
363	SURGE TANK FOR LECITHIN
362	SURGE TANK FOR FATS
361c	WEIGHING & BAGGING MACHINE
361b	WEIGHING & BAGGING MACHINE
361a	WEIGHING & BAGGING MACHINE
360	RIBBON BLENDER
359	PADDLE MIXER
358	CONVEYOR
357	MICRO PULVERISER
356	INTERMEDIATE MEAL STORAGE BIN
355	BLOWER
354	CYCLONE
353	MEAL COOLER
352b	GRINDER NO 2
352a	GRINDER NO 1
351b	SCREEN NO 2
351a	SCREEN NO 1
350	SURGE BIN FOR MEAL FROM DT
196	MEAL CONVEYOR FROM DT

SERVOTECH
POST BOX: 6073
BOMBAY ~ 5 (BR)

DRG.NO. FLS:FIN 89


27·5 M.
41·0 M.
35·0 M.
10·0 M.
16·0 M.
74·0 M.
BAGGING
FULL FAT SOY FLOUR
PREPARATORY SECTION
OIL MILL
FINISHIN
100
101
102
103
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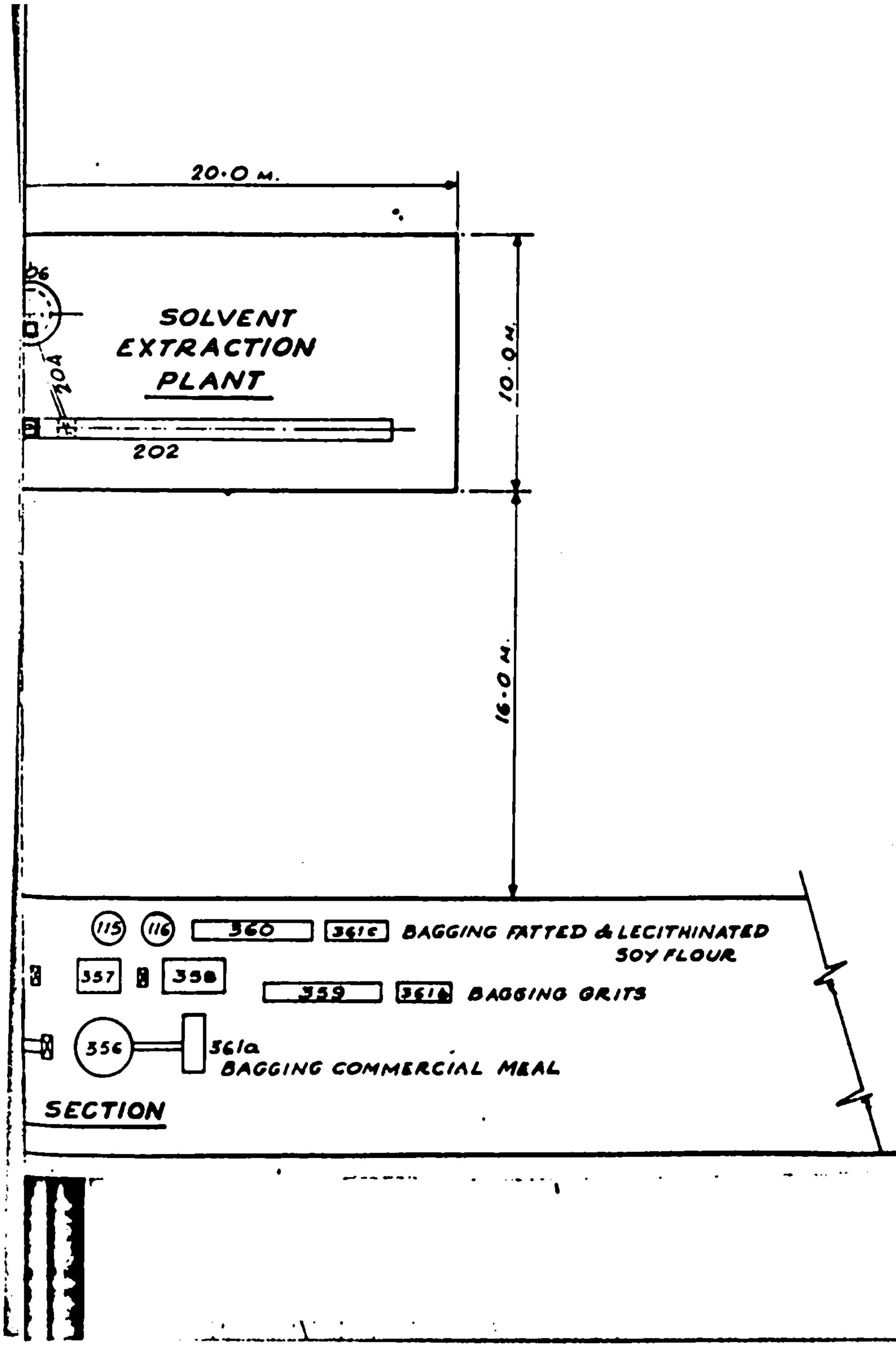
LAYOUT OF PREPARATORY & FINISHING SECTIONS

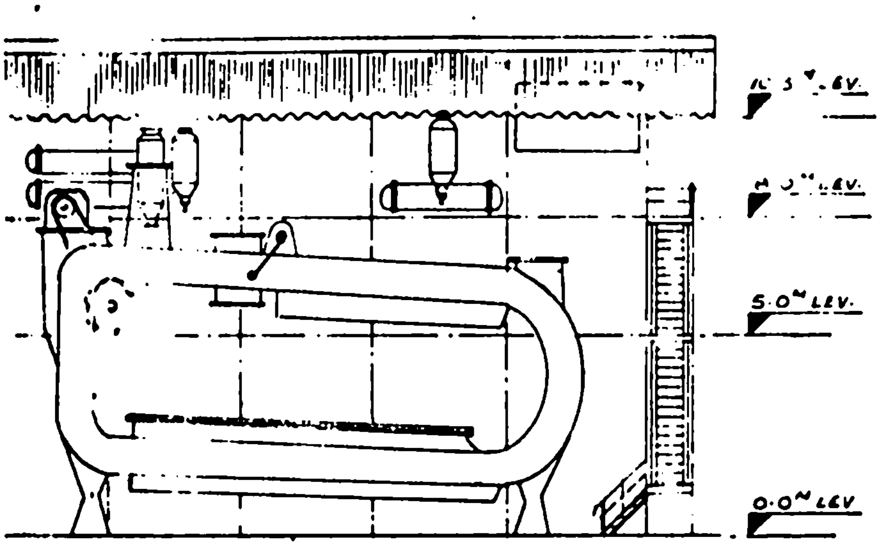


100	DAY BIN
101	SCREEN
102	DESTONER
103	GRAVITY TABLE
104	MAGNETIC DRUM
105	SURGE BIN
106	SCALE
107	CRACKER
108	SHAKER SEPARATOR
109	CYCLONE
110	BLOWER
111	CONDITIONER
112	FLAKER
113	HAMMER MILL
114	TOASTER
115	GROUND DOCKAGE STORAGE BIN
116	GROUND HULLS STORAGE BIN
151	CLEANER
152	DESTONER
153	GRAVITY SEPARATOR
154	MAGNETIC DRUM
155	SURGE BIN
156	DRIER
157	COOLER
158	CRACKER
159	SHAKER SEPARATOR
160	HULLS
161	MEATS
162	HAMMER MILL
163	STORAGE BIN
164	STEAM JACKETTED PRECONDITIONER
165	HIGH SPEED MIXER
166	HIGH TEMP COOKING EXTRUDER
167	CONVEYOR
168	COOLER
169	CRUMBLER
170	ROLLER MILL
171	CYCLONE
172	BLOWER
350	SURGE BIN FOR MEAL FROM D T
351	SCREEN
352	HAMMER MILL
353	MEAL COOLER
354	CYCLONE
355	BLOWER
356	INTERMEDIATE MEAL STORAGE BIN
357	HAMMER MILL
358	SCREEN
359	PADDLE MIXER
360	RIBBON BLENDER
361	BAGGING MACHINE & SCALE
362	SURGE BIN FOR FATS
363	GROUND HULLS STORAGE BIN

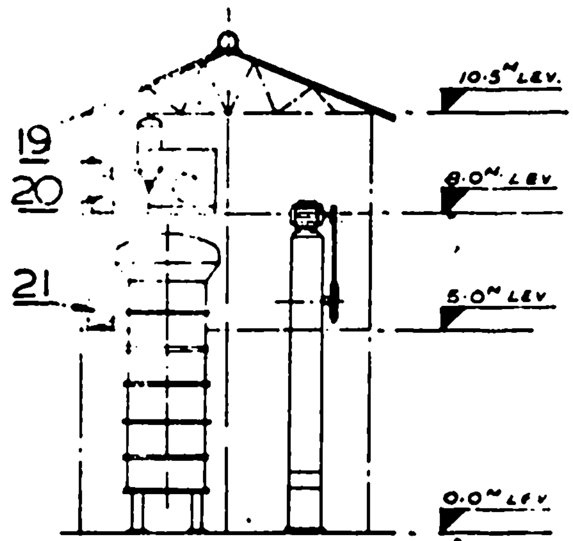
SERVOTECH

POST BOX: 6073
BOMBAY—5 (BR)

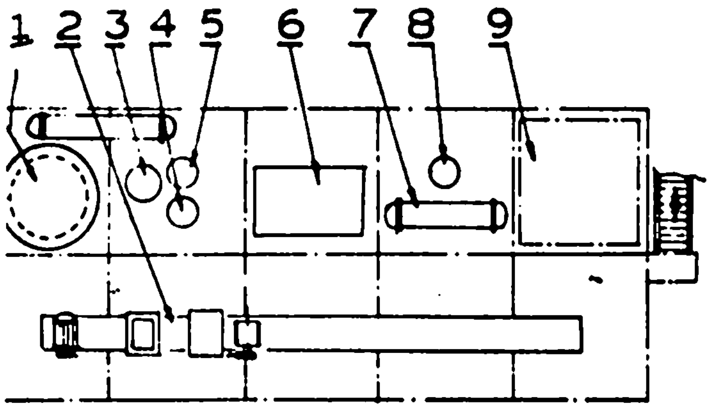
DRG.NO. LOT:PRF 80



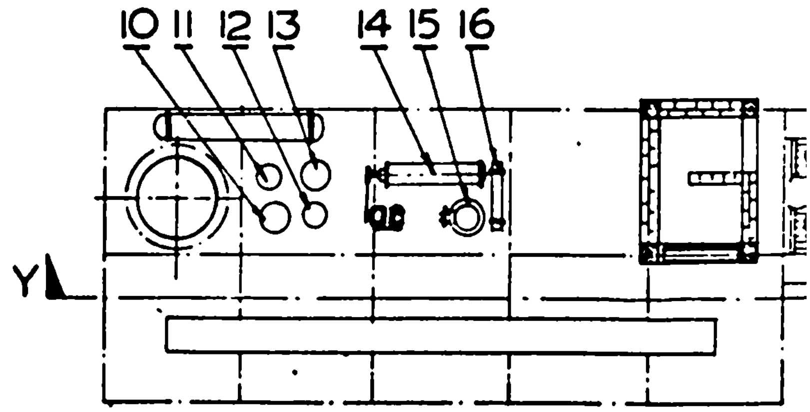
ELEVATION



SECTION XX

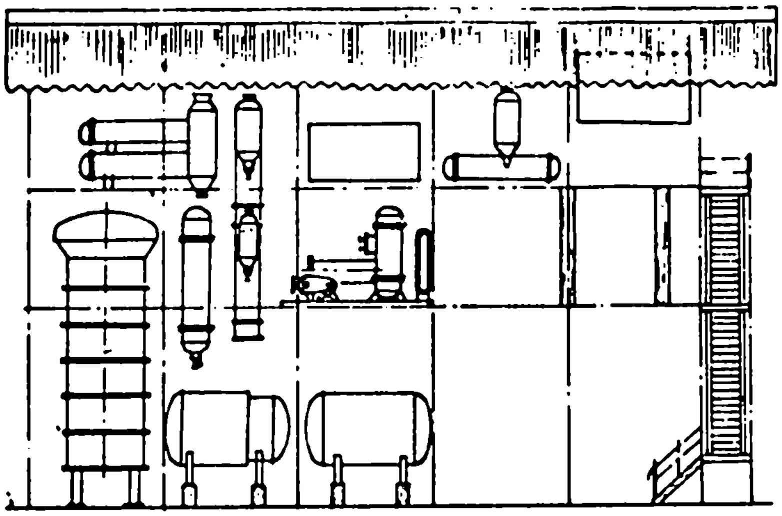


PLAN AT 8·0m. lev.

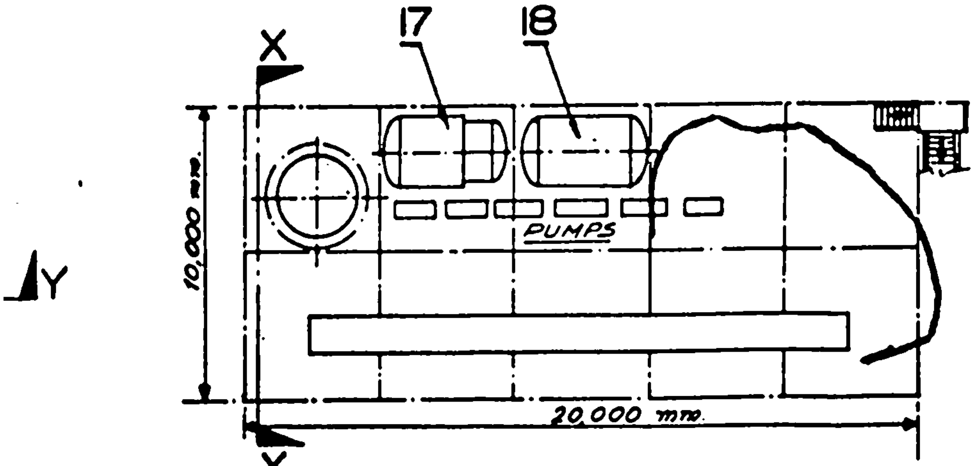


PLAN AT 5·0m. lev.

TYPICAL LAYOUT of the SOLVENT EXTRACT[illegible] PLANT



SECTION Y Y



PLAN AT 0.0 m. lev.

S. NO.	ITEM No.	DESCRIPTION
1	206	DESOLVENTSER TOASTER
2	202	EXTRACTOR
3	210	SCRUBBER
4	234	PRIMARY FLASHER
5	233	PRIMARY EVAPORATOR
6	238	FINISHED OIL STORAGE
7	240	ECONOMISER
8	241	FLASHER
9		EMERGENCY WATER STOR[illegible]
10	237	FINAL STRIPPER
11	H237	MISCELLA HEATER
12	236	SECONDARY FLASHER
13	235	SECONDARY EVAPORATO[illegible]
14	213	SOLVENT ABSORBER
15	214	SOLVENT EVAPORATOR
16	215	SOLVENT COOLER
17	218, 231, 219	WATER SOLVENT SEPARATOR, SOLVENT RESERVOIR, EFFLUENT[illegible]
18	232	MISCELLA RESERVOIR
19	217	CONDENSER
20	216	CONDENSER
21	211	CONDENSER

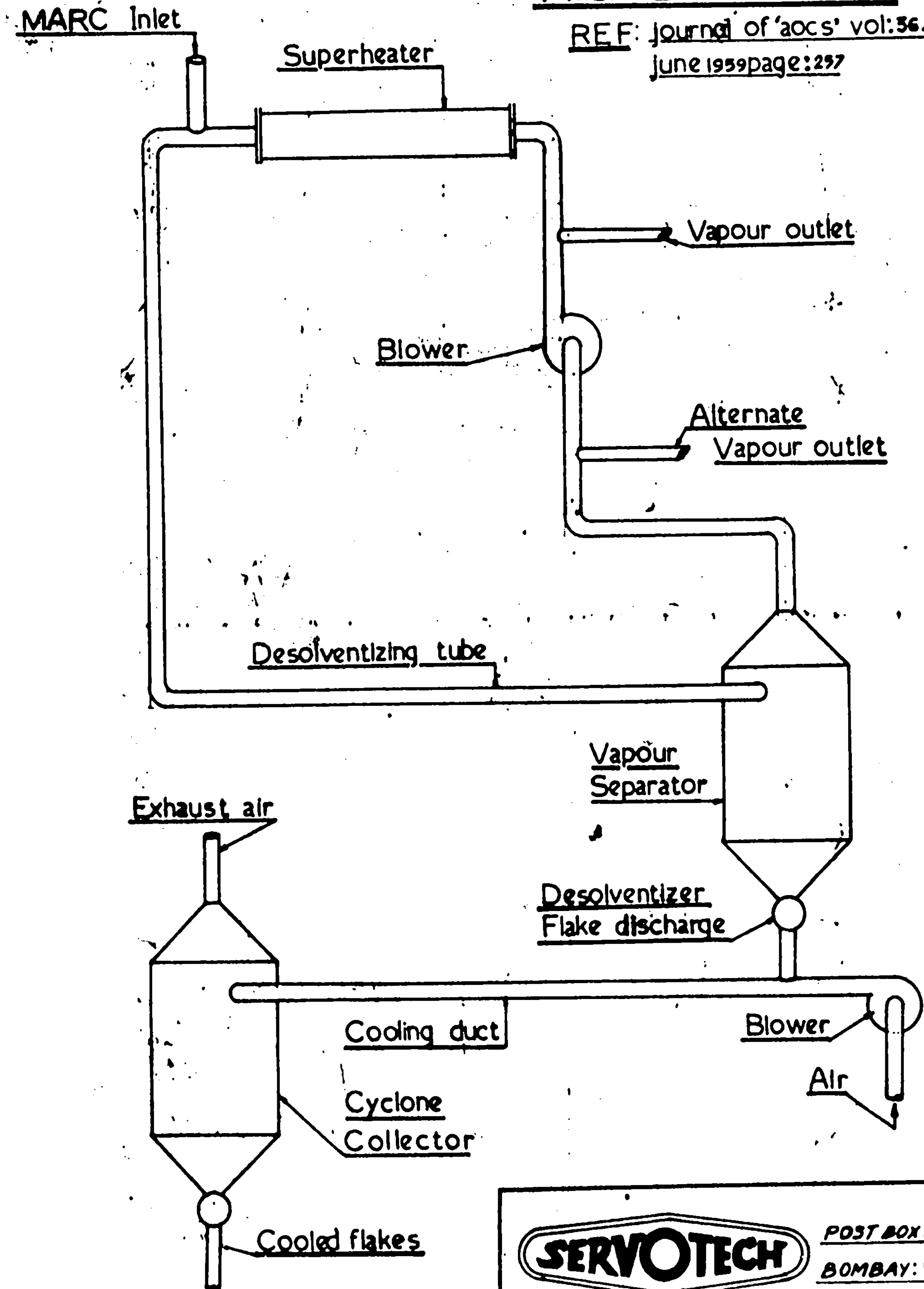
ACKNOWLEDGEMENT :- EXTRACTOR CO[illegible]
CROWN IRON WORK[illegible]

SERVOTEC[illegible]
POST BOX: 6[illegible]
BOMBAY-5 B[illegible]

DRG NO.
LOT: SEP 81

Flow Diagram Of Flash Desolventizer

REF: journal of 'aocs' vol:36. june 1959 page:257



SERVOTECH

POST BOX: 6079
BOMBAY: 5 (BR)

DRG.NO. SK: 95.