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ASSISTANCE TO THE ANTIBIOTICS INDUSTRY

SI/DRK/88/802

DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA

Technical Report: Evaluation of Sunchon Pharmaceutical Plant
Antibiotics Division - Down Stream Processing
and Suggestions for Improvement*

Prepared for the Government of the Democratic People's Republic of Korea
by the United Nations Industrial Development Organization
acting as executing agency for the United Nations Development Programme

Based on the work of Mr. K.R. Desikan
Expert in Downstream Processes

Backstopping Officer: Ms. M. Sanchez, Chemical Industries Branch

United Nations Industrial Development Organization
Vienna

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*Mention of firm names and commercial products does not imply the endorsement of UNIDO. This document has not been edited.

V.89-62145

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Evaluation of the Sunchon Pharmaceutical Plant - Antibiotics Division

Down stream processing and suggestions for improvement.

Initial discussions were held with the Trade Director of the Pharmaceutical Industry, Mr. Kim Gyu Hwan. A schedule was chalked out and accepted. We were assisted in the discussion by Mr. Chang Sun Gi and Mrs. Jonk Gyong Suk who acted as the interpreter.

In the Sunchon factory we were assisted by Mr. Sing Yong uk, Chief Engineer and Mr. Chang Ryong Hui, Principal Engineer for Technical Development

For the general description of the plant and the basic aspects refer SI/DRK/88/802-11-01. report.

2. Penicillin - Down stream processing.

2.1. Harvest.

There is 20 M^3 mild steel receiving tank. The harvest line along with the vessel is steamed. The broth is sent under pressure to the receiving tank. Air is sparged through a sparger and the contents are circulated by a pump, 15-20 lts of formalin is added to the broth whose potency is 17,000 u/ml.

2.2 Filtration.

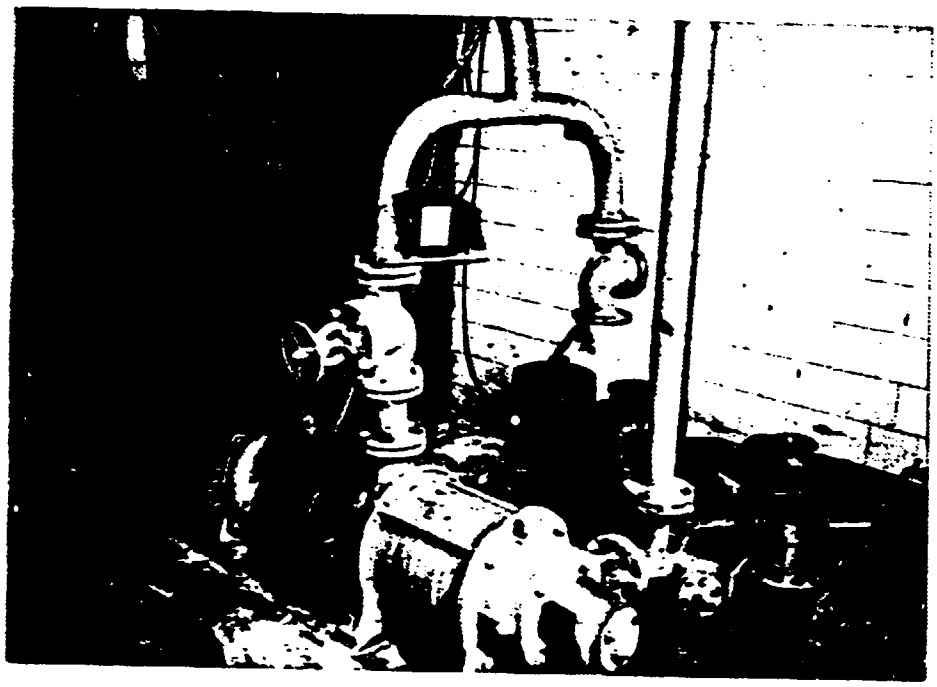
From the holding tank the broth is pumped with the help of a pump, with a capacity of 40 M^3/hr. Temperature of the broth is 18°C. After adjusting the pH with H_2SO_4 to 5.5 - 5.8, it is pumped to the filter press. There is one cast iron filter press with 26 plates and 26 frames approximately 40 sq.mt. area.
The broth from one fermenter 10.5 M^3, takes 8 hours. After 4 hours the filter press is choked. The vinalon impregnated cloth is removed after dismantling the plates and frames. The filter press head is operated under hydraulic pressure instead of motorised version. In order to dismantle, the pressure is removed by draining the water from the head and the plate head moves back as it is already weighed down with heavy metal cylinders on both sides. It is claimed that the cloths are used for 50 batches at a stretch, though from the appearance it looks more used.

2.3. Coagulation and removal.

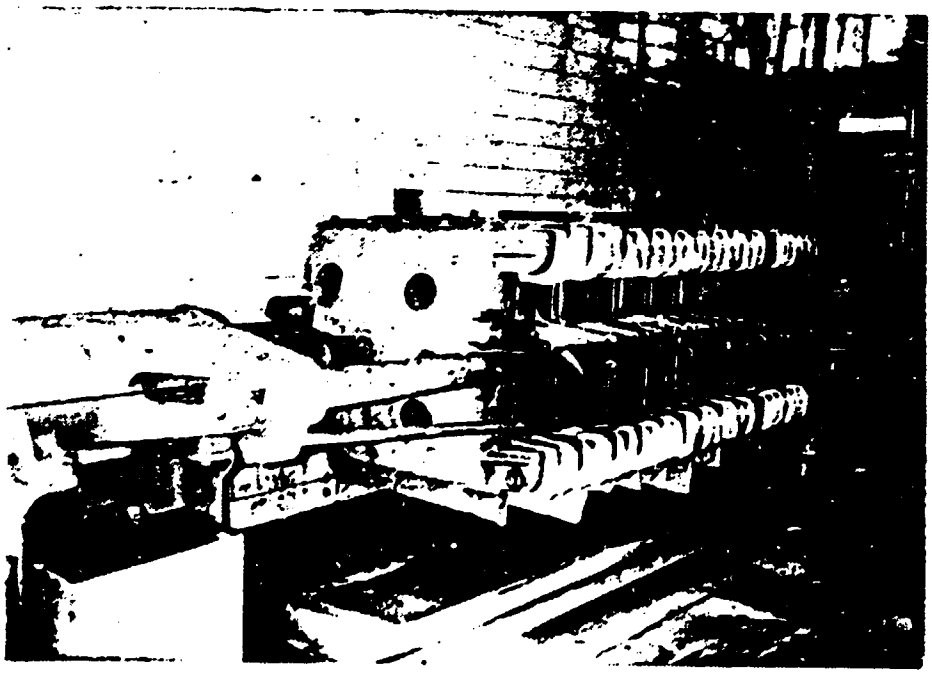
After the addition of water to remove the broth filtrate from the filter press, the volume now reaches approximately 15 M^3 with a potancy of 10,000 - 11,000 u/ml.
The filtrate under pressure is taken through a steam coil where the temperature of 70 - 80°C is reached and maintained for approximately 2 minutes. Immediately it is sent through a cooling coil with water in the outer cover and then through brine coil to reduce the temperature to 15°C. There is an intermediate receiving SS tank of 3.5 M^3 capacity. Here 0.3 % deemulsifier is added.
The coagulated proteins are removed by centrifuging.
There are 2 bowl centrifuges with 13,000 rpm and dirt holding capacity of approximately 8 lts. Their capacity is around 9 M^3/hr. Approximately 8 kg of proteins are removed.
The potency loss is around 8 % leading to the filtrate now at 9,500 - 10,500 u/ml.

2.4 Extraction.

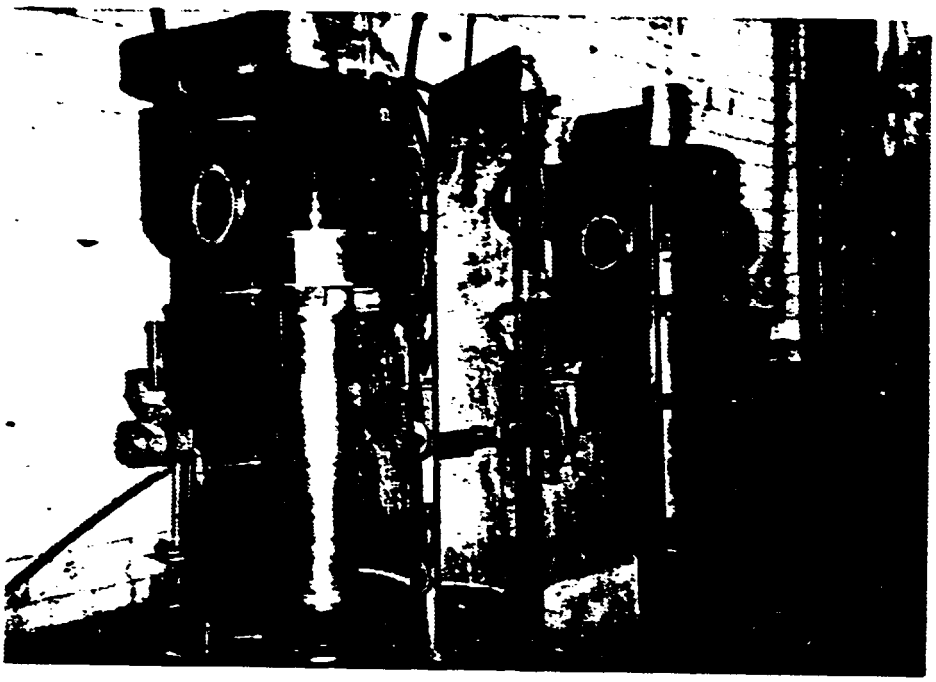
There are two Lugor Westfalia counter current extractors (from



Penicillin–Broth Pump

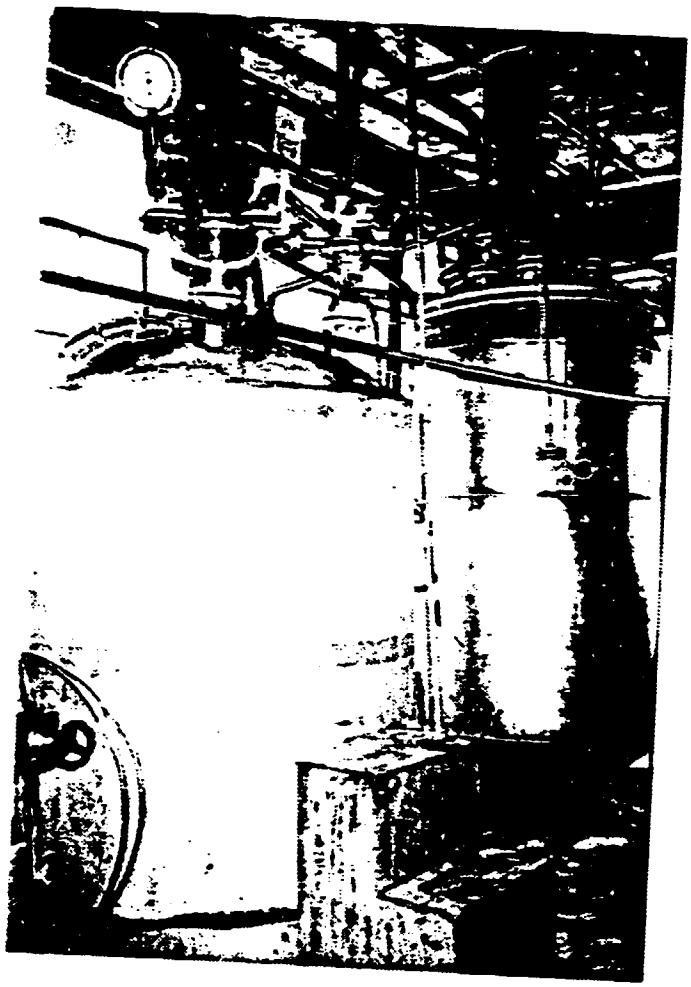


Penicillin–Filter Press

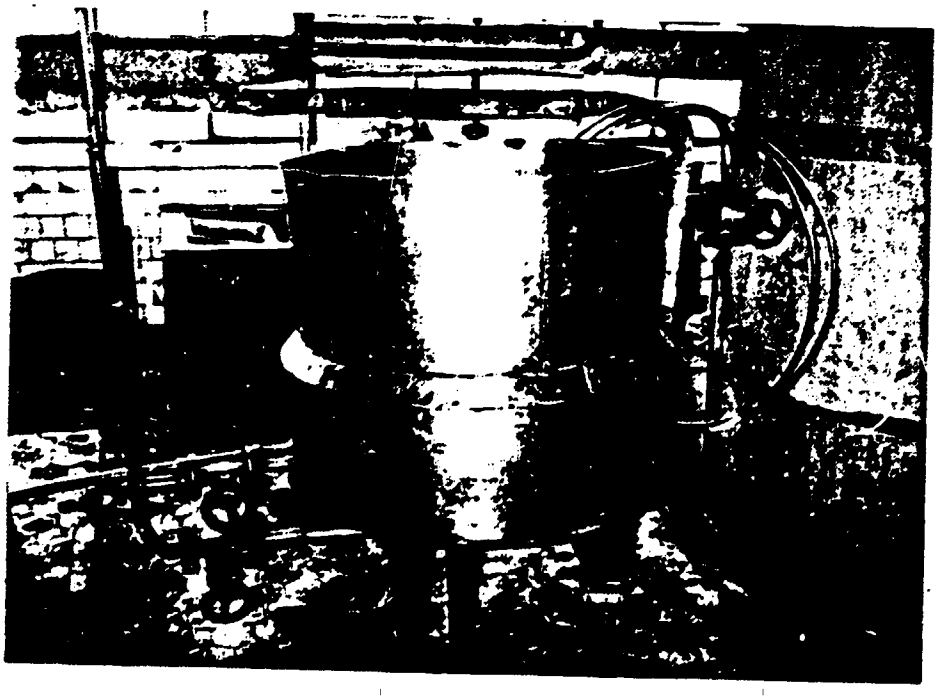


Penicillin-Centrifuge

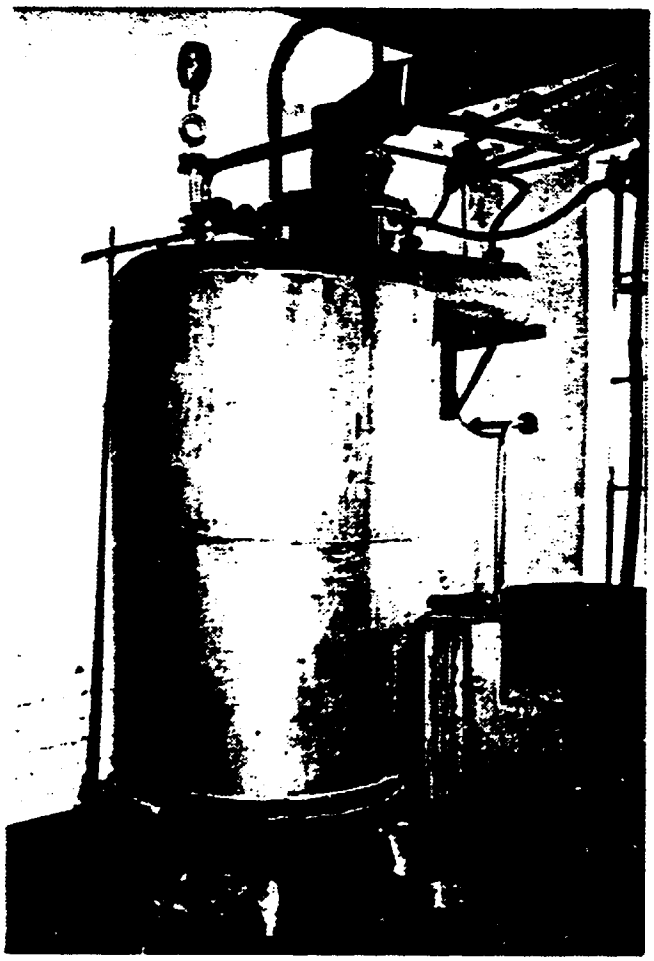
Penicillin-Extractor



Penicillin-Decolourization



Activated Carbon Filter



POT - Penicillin Storage Tank
after decolourization

Oelde, West Germany). The extractor is connected with SS pipe lines for broth feeding, for feeding solvent and for feeding sulphuric acid. The broth at pH 2.0 - 2.2 is extracted with Butly acetate.The extraction is run at 2 M^3/hr and it takes 8 hours. Thebutly acetate is fed at 600 - 700 lts/hr. The extract volume is around 4.5 - 5.0 M^3. The spent broth contains 15 % of the original potency but is discarded .

2.5 Treatment.

This extract is divided into 3 portions of approximately 1.6 M^3 each. It is taken in a 2 M^3 SS tank. Acidified water 50 lts is added onto this extract at pH 2.0. The extract is then decolourised with activated carbon in an SS tank 2 M^3 capacity. Activated carbon at 0.5 % is added depending upon the potency of the extract. The contents are stirred for 2 hours. They are filtered through a open vacuum basket filter and then stored in an SS 2 M^3 tank.

2.6. Conversion.

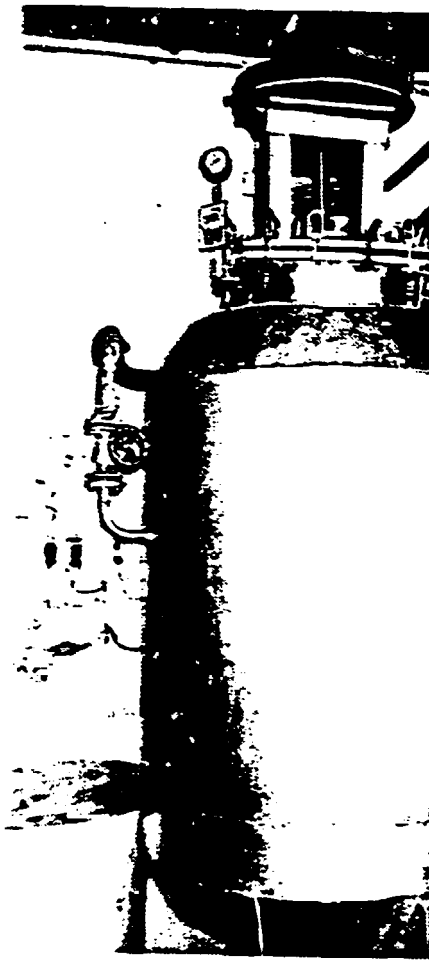
From the storage tank the decolourised extract at 35,000 - 40,000 u/ml is transferred to another room to a 2 M^3 SS tank with brine coils. It is chilled to 5°C. Under continous stirring potassium-bicarbonate is added 4 times totalling to 15 kg. After 80 % first addition and stirring the bottom heavy layer is removed and the potassium bicarbonate addition with water 45 lts is carried out 3 more times.Almost 97 % of potassium penicillin is recovered.The heavy layers are taken in 100 lts SS tank where pH is adjusted to 6.8 - 7.2. The concentration is now in the range of 50,000 u/ml.

2.7. Purification.

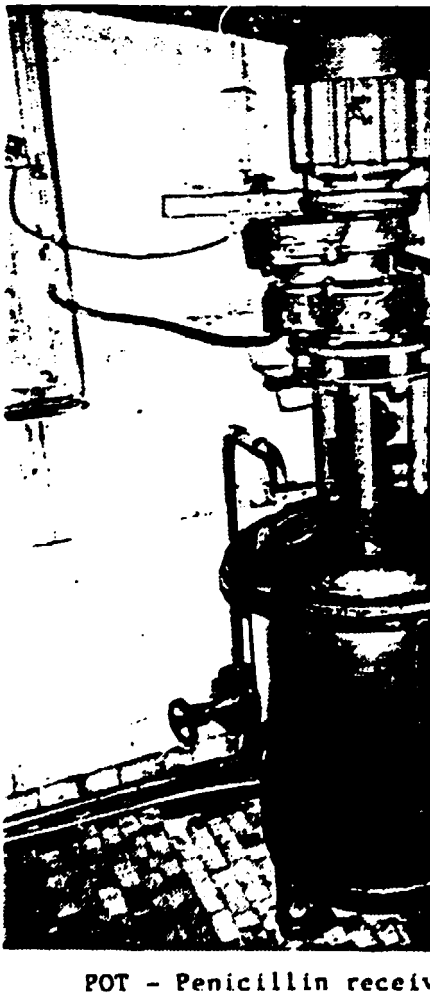
Final purification is done in an adjecent sterile area where the treatment, the filters, the centrifuge and the drier are located. The 200 lts treatment tank receives the solution where 100.lts of Butanol is added. The whole mixture is sent through sterile filter under pressure. This has bacterial filter as well.

2.8. Distillation.

There are 2 SS tanks of 900 lts capacity with M.S. jacket. The vessel is presterillised. After receiving the filtered soloution 200 - 450 lts of filtered Butanol is added again in this vessel. The contents are stirred with hot water in the jacket (80°C) to 45 - 47°C under vacuum for 3 - 4 hours. Azeotropic distillation is carried out with brine in the condensor. When 35 - 40 % is distilled of, which is verified by the indicator in the collecting vessel the distillation is stopped. The contents are cooled to 20°C.



POT - Penicillin pr

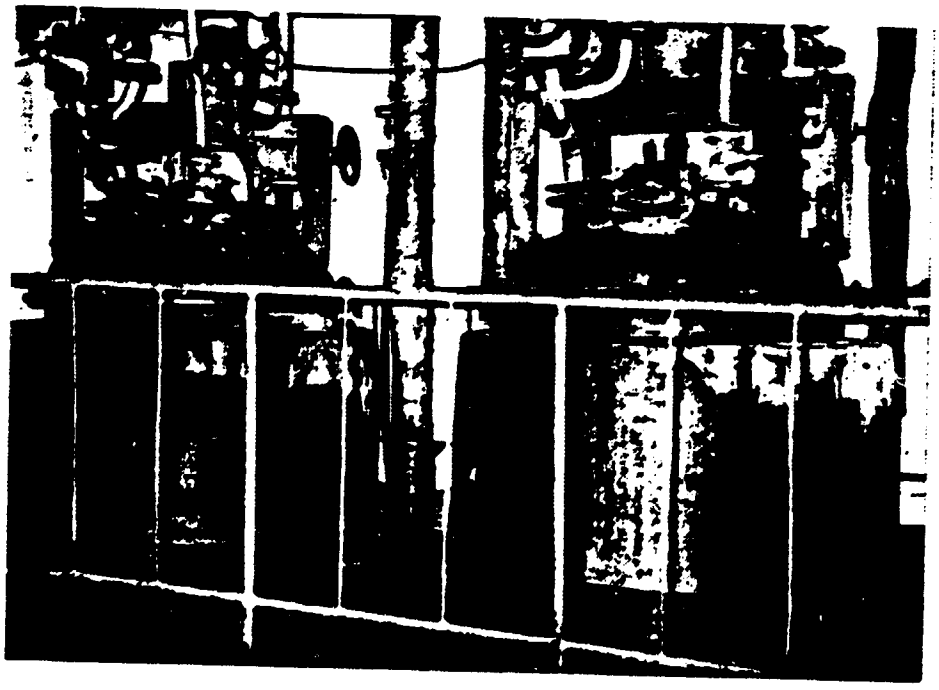


POT - Penicillin recei

precipitation

iving tank

POT - Penicillin Butanol Treatment



POT - Penicillin Azeo. distillation

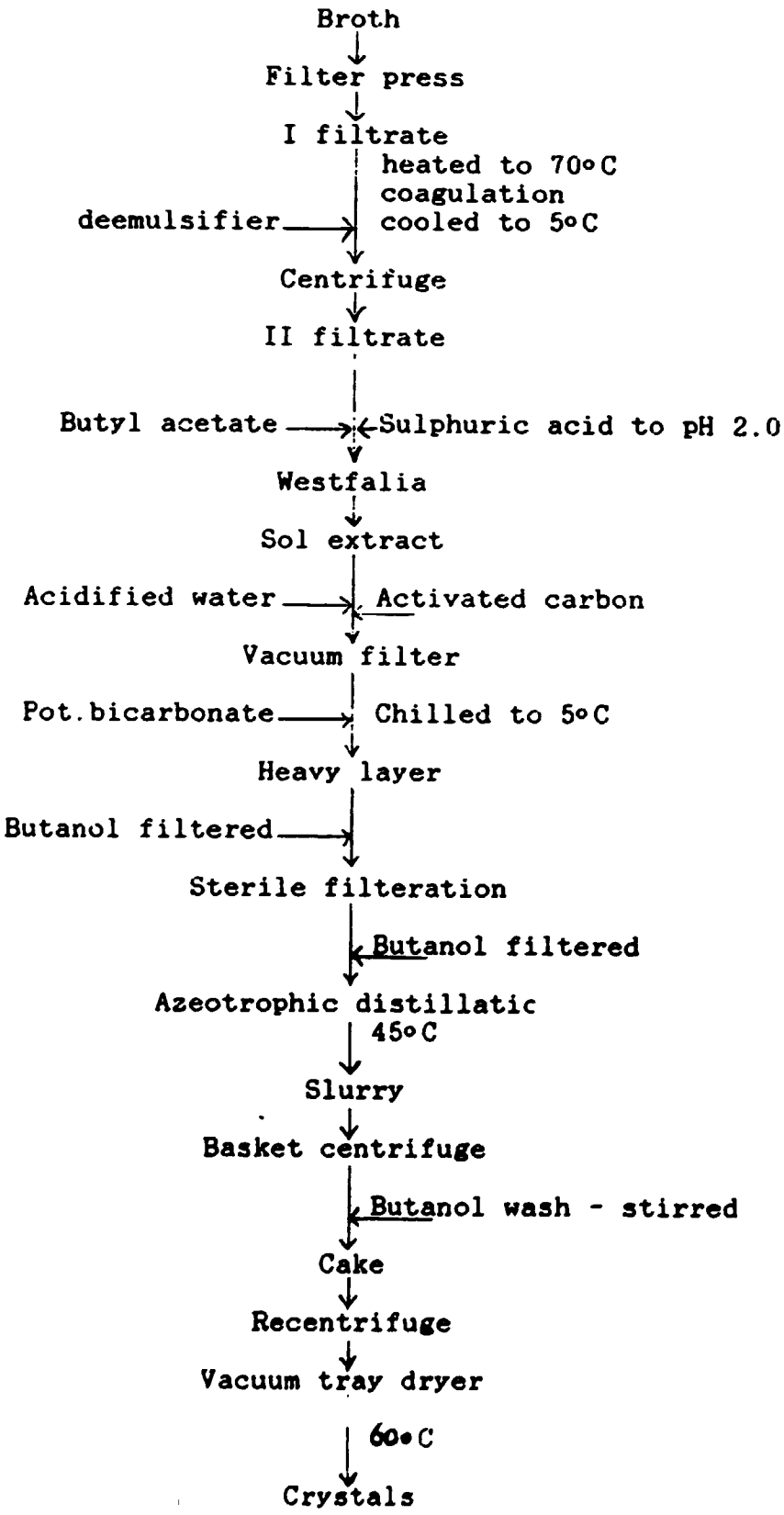
2.9. Centrifugation.

There are two basket centrifuges that can take 20 kg at a time when they are run for an hour. The wet crystals are washed with Butanol 3 times in SS tank where it is thoroughly stirred. The contents are centrifuged and the crystals removed in lumps.

2.10. Drying.

The crystals are removed and put in trays, spread out and put in vacuum dryer at 60°C for 15 hours. The lumps are put through a grinder and then packed in 10 or 20 kg polyethylene bags.

2.11 Flow sheet



3. Oxy tetracycline - down stream processing.

3.1 Broth treatment.

There are 4 receiving tanks of 9 M^3 capacity. The broth potency is 10,000 u/ml and volume is around 10.5 M^3. The pH of the broth during harvest is around 6.0 - 6.2. The broth pH is adjusted to 2.0 with oxalic acid (2 - 2.5 %). Then potassium ferrocyanide is added at 0.2 - 0.3 % followed by zinc sulphate at 0.1 - 0.2 %. This precipitates all heavy metals. The contents are stirred for 60 minutes.

3.2 Filteration.

There are 4 cast iron filter presess of 40 sq. metre each. They are same as described for penicillin in construction and working. It takes 15 hours to filter 10.5 M^3 broth through all the 4 filter presses. The filterate is collected at the bottom of the filter press in a SS trough. The filtrate from here is pumped to two 1 M^3 SS tanks. After pressing with water the total volume works out to 15 M^3.

3.3 Filterate treatment.

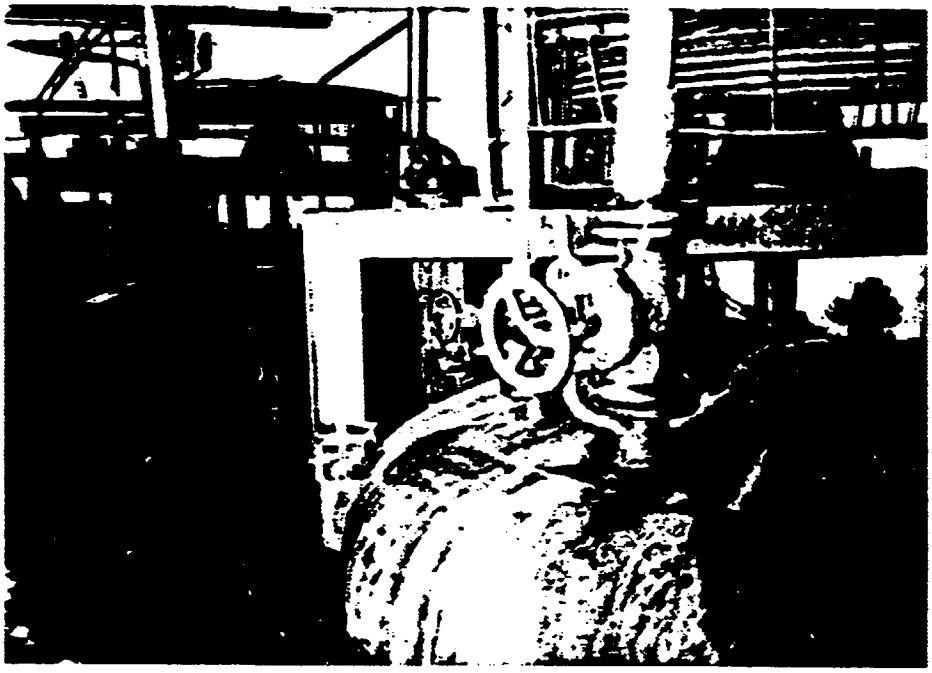
The filterate in small batches is treated with sodium hydroxide to pH 4.5 and 0.3 % sodium sulphite. This treatment is carried out in another area where there are 10 SS vessels of 1 M^3 capacity. The contents are stirred for 6 hours till the precipitation of oxytetracycline is complete.

3.4 Precipitate removal.

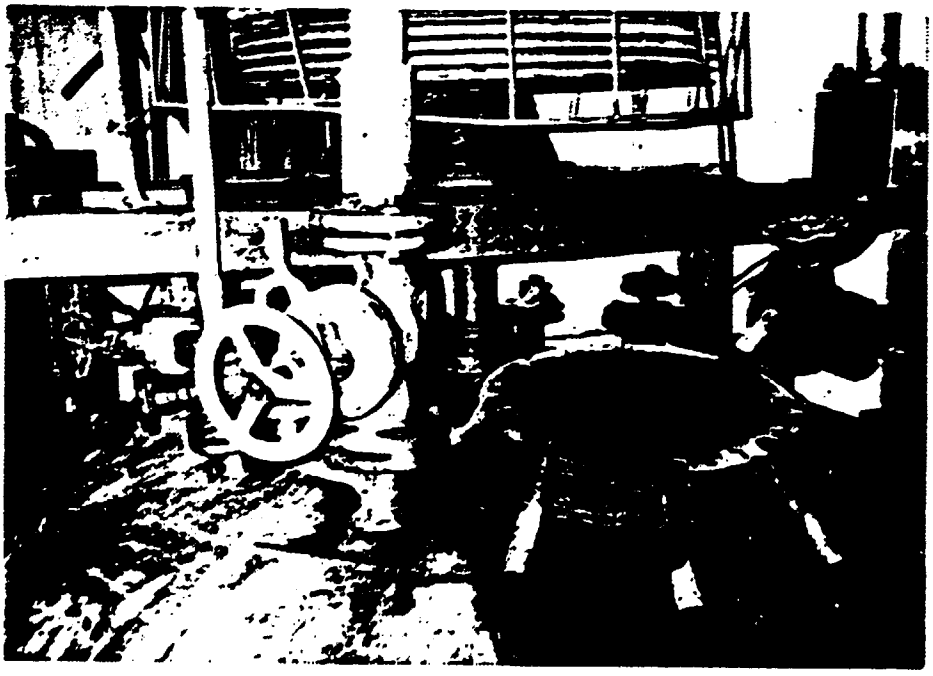
The precipitate with the mother liquor is pressed through a small cast iron filter press. The same vinalon impregnated canvas cloth is used. The plates and frames are of 0.5 metre square with 6 plates and 6 frames. The spent liquor with 1,500 u/ml potency is discarded.

3.5 Drying.

The wet precipitate weighing approximately 100 kg/batch is dried in tray dryers at 60°C. The brown powder after drying weighs approximately 73 kg/batch.

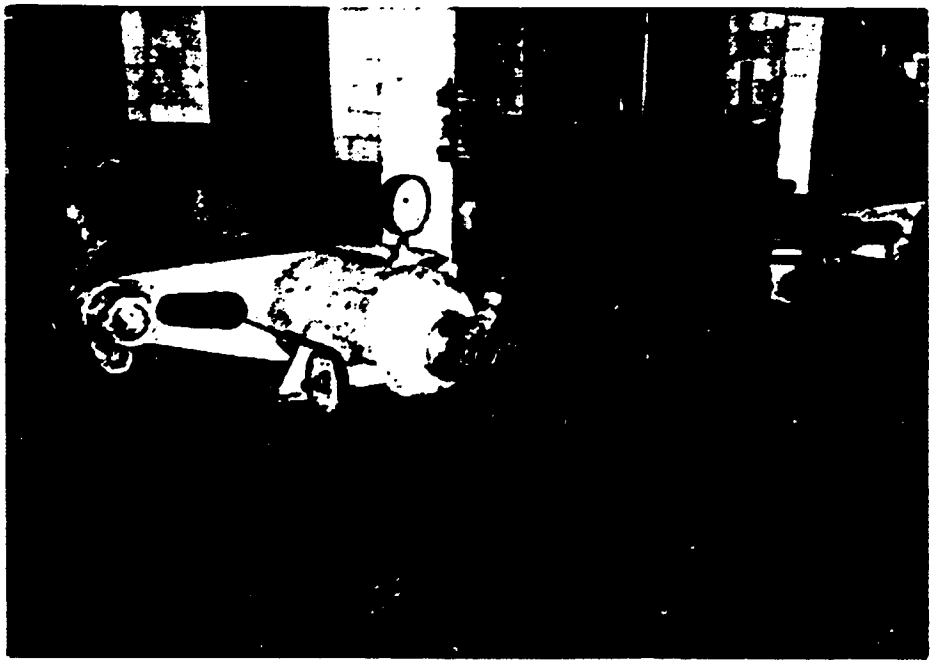


OTC Broth receiving tank



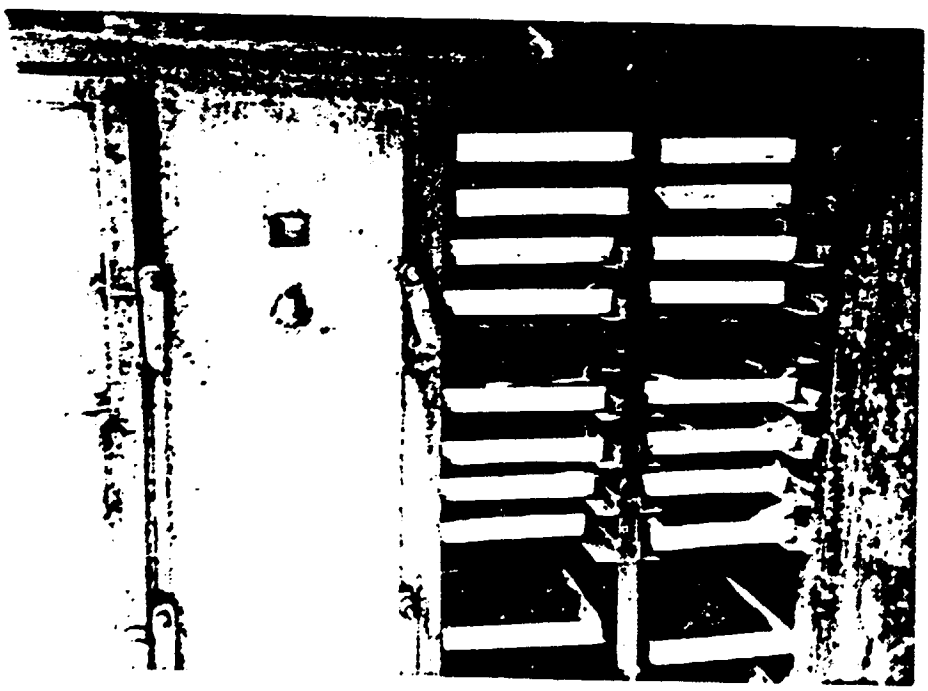
OTC Broth receiving tank-top view

OTC Filtration



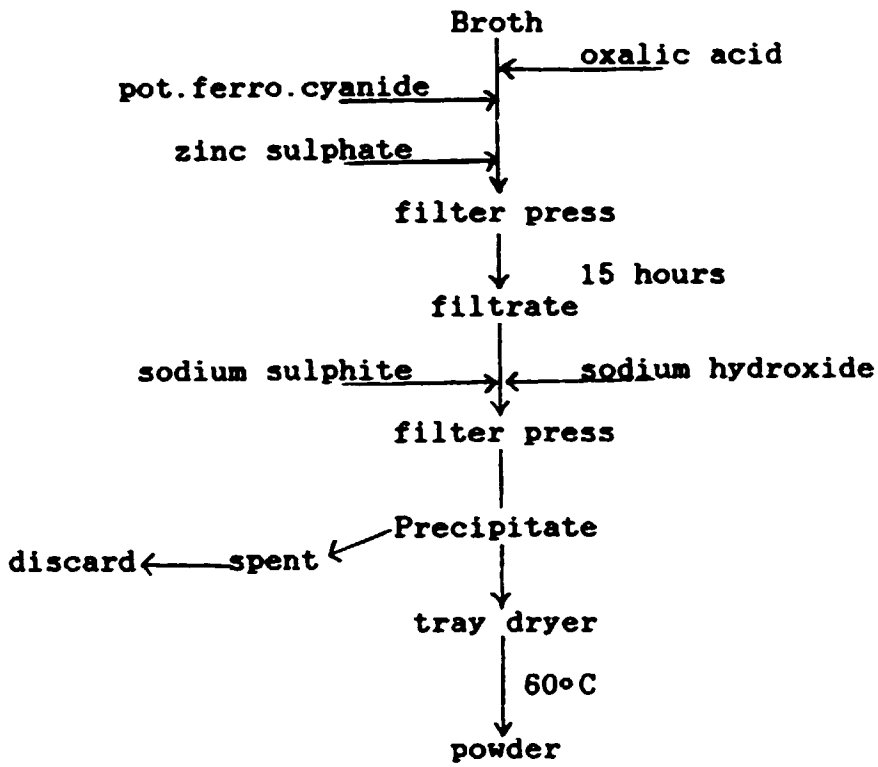
OTC Filterpress head

OTC Treatment Tank



OTC Tray drying

3.6 Flow sheet.



4. Kanamycin - Down stream processing.

4.1. Broth treatment.

4.1.1.The broth with approximate pH 7.5 is received in one of the two carbon steel tanks of 25 M^3 capacity. The average yield is stated to be in the range of 4,000 u/ml. 10 % sulphuric acid is added to this broth to bring down the pH to 6.5. The contents are stirred and then oxalic acid 0.15 % is added to bring the pH to 6.2. The contents are stirred for 0.5 hour.

4.1.2.Water is added to dilute the potency to 3,000 u/ml. The total volume now stands around 14 M^3. Wofatit KPS a resin from the German Democratic Republic probably a subsitute for IRC 50 (NH_4^+) ROHMHAAS, 400 kg is added to the broth, pH goes up to 6.7 -6.8. The contents are stirred for 8 hours.

4.2 Mycelium removal.

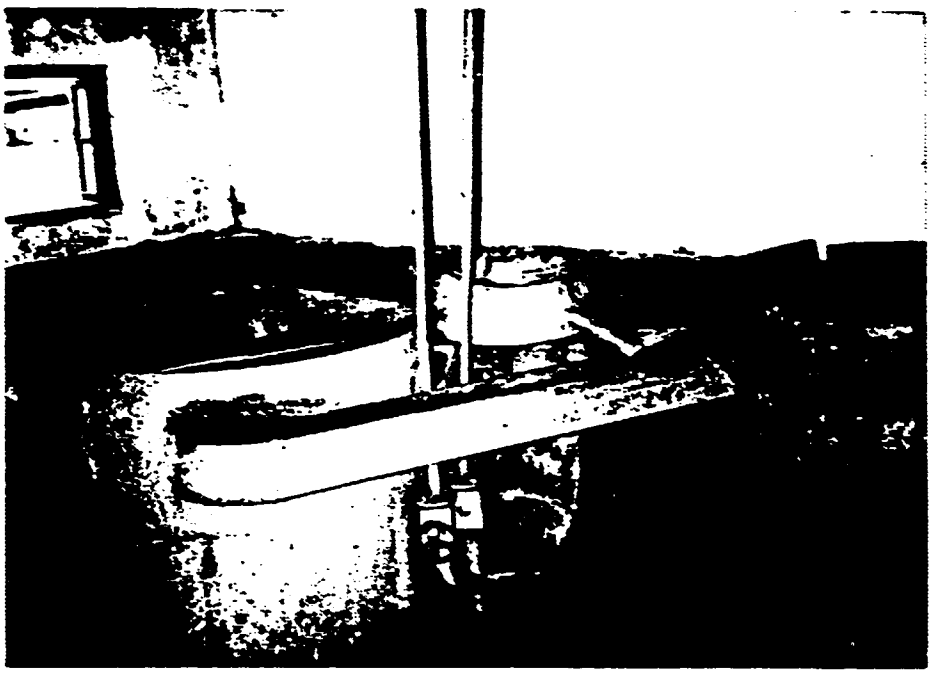
4.2.1.The whole broth along with the resin is allowed to flow into an open metal container of approximately 300 lts. Here the heavy resin gloubles settle at the bottom along with some mycelial mass. The broth overflows through an open conduit to the second metal contaier wherein the resin again tends to settle allowing the mycelium to float away. From the second metal container the broth over flows through 6 concrete tanks of diffrent capacities ranging from 200 to 500 lts.In the first 3 tanks there are still resin residues at the bottom leaving the last 3 with only the broth. The final spent over flow contains less than 50 u/ml.

4.2.2.The resin settled at the bottom of the tanks is washed several times with water to remove the mycelia adhering to it. The recovery of potency is 90 %. The resin is then scooped up in metal containers and then transported to another adjecent area for column chromatography.

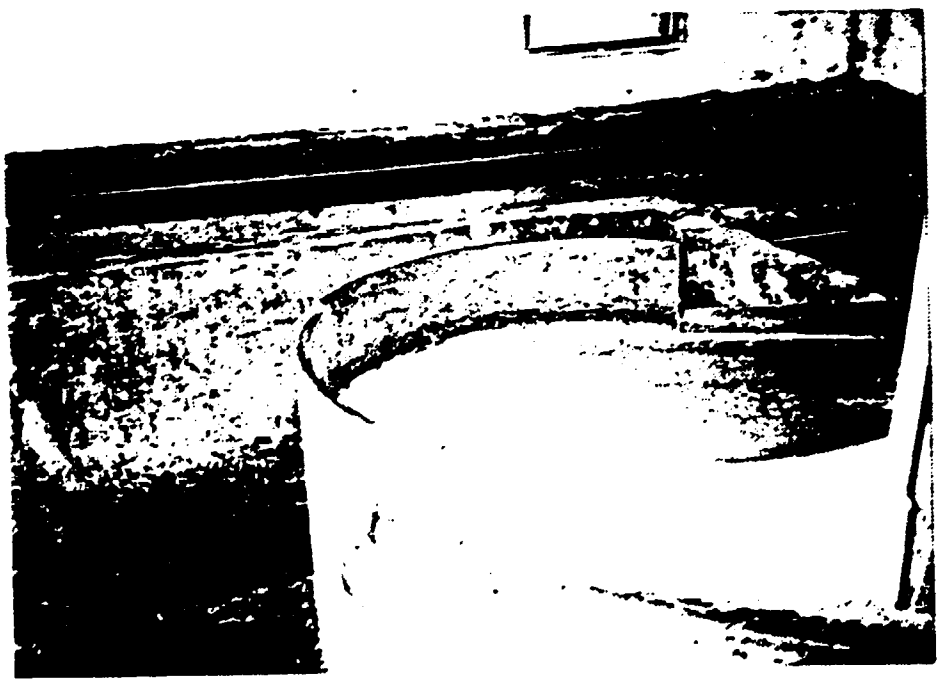
4.3. Coloumn cnromatography.

4.3.1.The coloumns 6 in number are of mild steel with rubber coating inside. They are 2 meters long and 60 cm in diameter. There are 4 sieves of PVC on the top and the bottom.

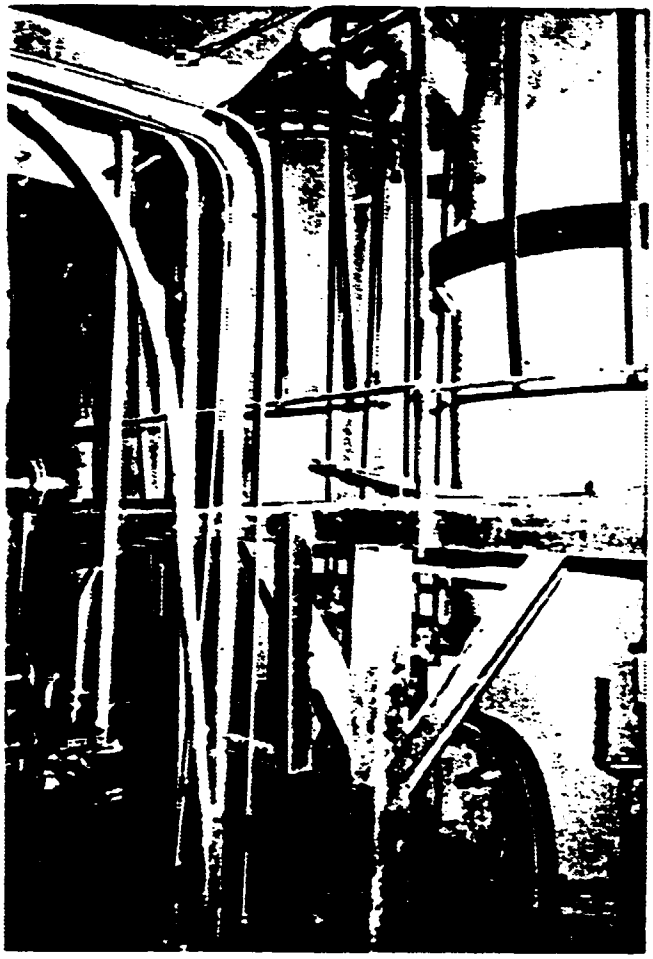
4.3.2.The resin 400 kg scooped from the tank is packed in one coloumn. It is washed with demineralised water 250 - 300 lts.
The potency of the outlet water is checked. The resin is eluted with 1.2 N ammonium hydroxide.
Approximately 800 lts are passed through the coloumn which takes 45 hours. The eluates are collected which are colourless in 3 SS tanks of 300 lts each. transferred to a pressure tank from where it is pressurised and sent to the first floor for concentration. Potency at this stage is 40,000 u/ml.



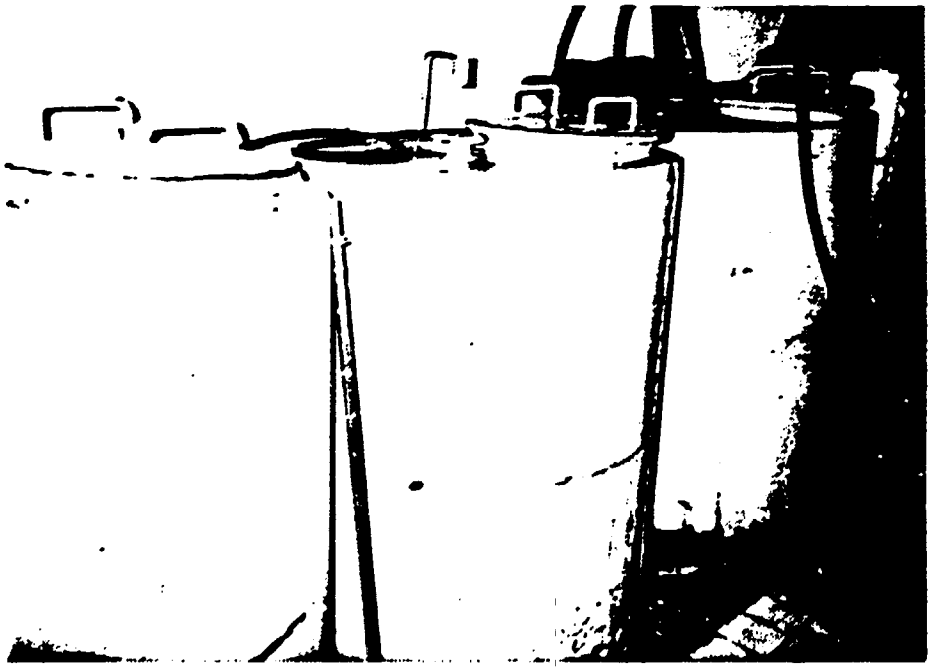
Kanamycin–Overflow tanks
(Mycelium removal)



Kanamycin–Overflow wier metal tank



Kanamycin–Chromatography columns



Kanamycin-eluate receiving tanks

Kanamycin-eluate receiving tank
(closed)

4.4. Resin regeneration.

4.1.1.After elution the resin is washed with demineralised water 250 lts/hour for 1 or 2 hours. 2 M^3 of 4 % hydrochloric acid is passed through the resin.

4.1.2.It is again wased with demineralised water till the acid is removed. The pH of the wash is around 3.5.

4.1.3. 2 M^3 of 4 % sodium hydroxide is passed through the coloumn. Again the resin is washed till the pH of the effluent is around 8.0.

4.1.4.There is a manhole at the side of the coloumn near the bottom which is opened to remove the resin to be taken back to the mixing vessel.

4.5. Eluate concentration.

There are 2 vacuum distillation units. One of them is provided with a stirrer which goes right up to the bottom of the coloumn. The eluates are fed at the top at 100 lt/hr. The jacket is heated with steam. The top concentrates in a secondary vessel up to 50 lts which is redistilled. The concentrated eluate from the bottom is collected in a 200 lts SS receiving tank in ground floor. The eluates get concentrated to 100 lts with a potency of 350,000 u/ml.

4.6. Eluate treatment.

4.6.1.The concentrated eluates are sent under pressure to stirred SS tank of 500 lts capacity in the first floor (located in the same area as the distillation units) the eluates are tested for potency and specific gravity.

4.6.2.The pH of the eluate is now adjusted to 8.2 with 50 % sulphuric acid approximately 8 - 12 lts.It is stirred throughly and methanol 50 % approximately 60lts is added to the eluate.

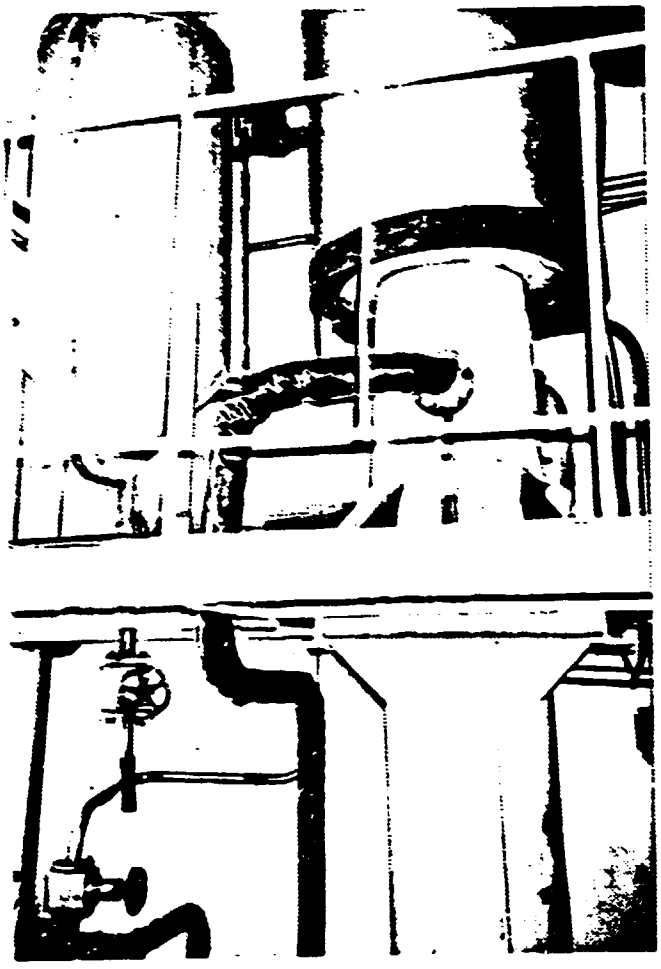
4.7. Crystallisation.

4.7.1.Temperature is maintained at 36 - 38°C by steam in jacket. The crystallisation is complete in 8 hours time. It is slowly cooled to room temperature.

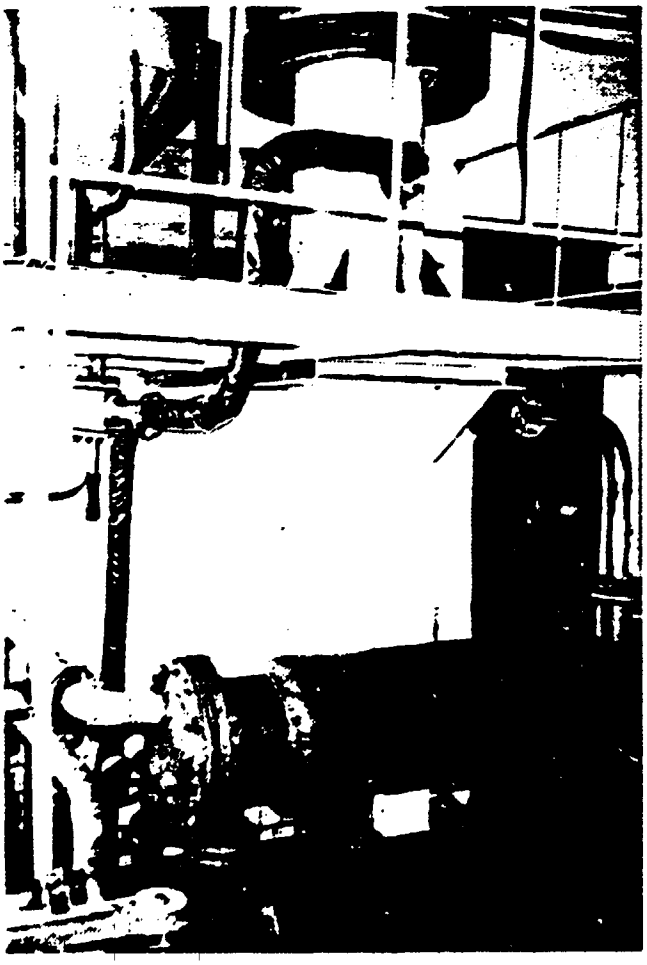
4.7.2.In an open SS vacuum filter three layers of cotton cloth are spread. The crystals are filtered through this filter. The wet mass is washed with 50 % methanol. Aproximately 6' -80 kg of kanamycin base is obtaineed.

4.8. Decolourisation.

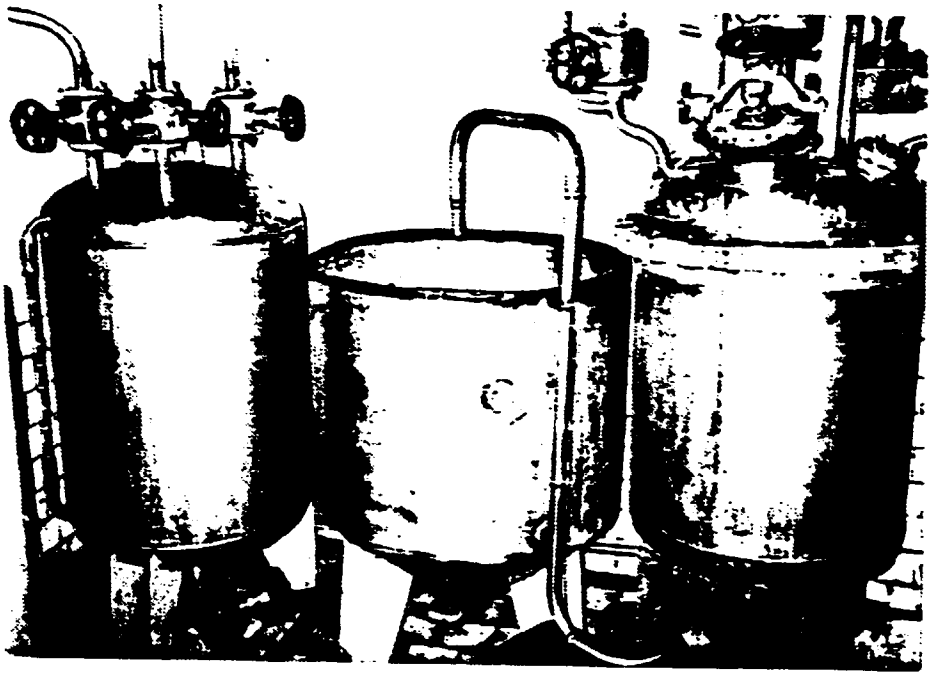
4.8.1.Decolourisation is carried out in an SS tank 250 lts



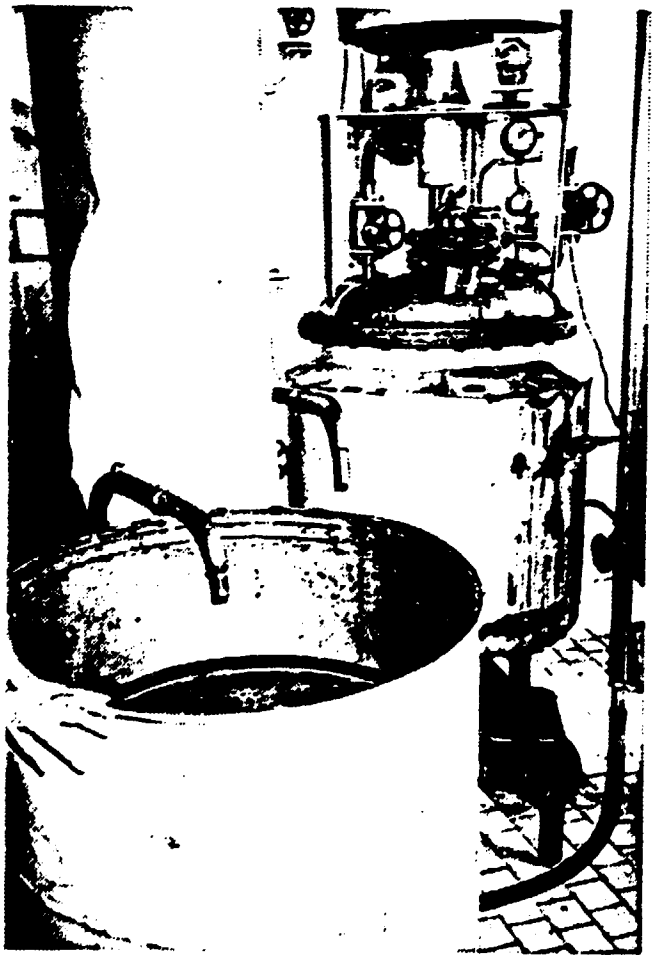
Kanamycin-eluate distillation
(top)



Bottom



Kanamycin-Crystallization



Kanamycin-
Decolourization

capacity. The cake is taken in this vessel and approximately 100 lt of distilled water is added. The contents are stirred and the pH is adjusted to 7.0 - 7.2 with 50 % sulphuric acid. Activated carbon approximately 10 %, 8 kg is added to the sllury and stirred for 60 minutes.

4.8.2.The contents are filtered through the same type of open SS vacuum filter to the sterile area. Approximate pH is 7.0, potency 150,000 - 180,000 u/ml and volume 100 lts.

4.9. Recrystallisation.

4.9. Recrystallisation is done in sterile area.

4.9.1.The solution is taken through sterile filter, containing bacterial filter packs.

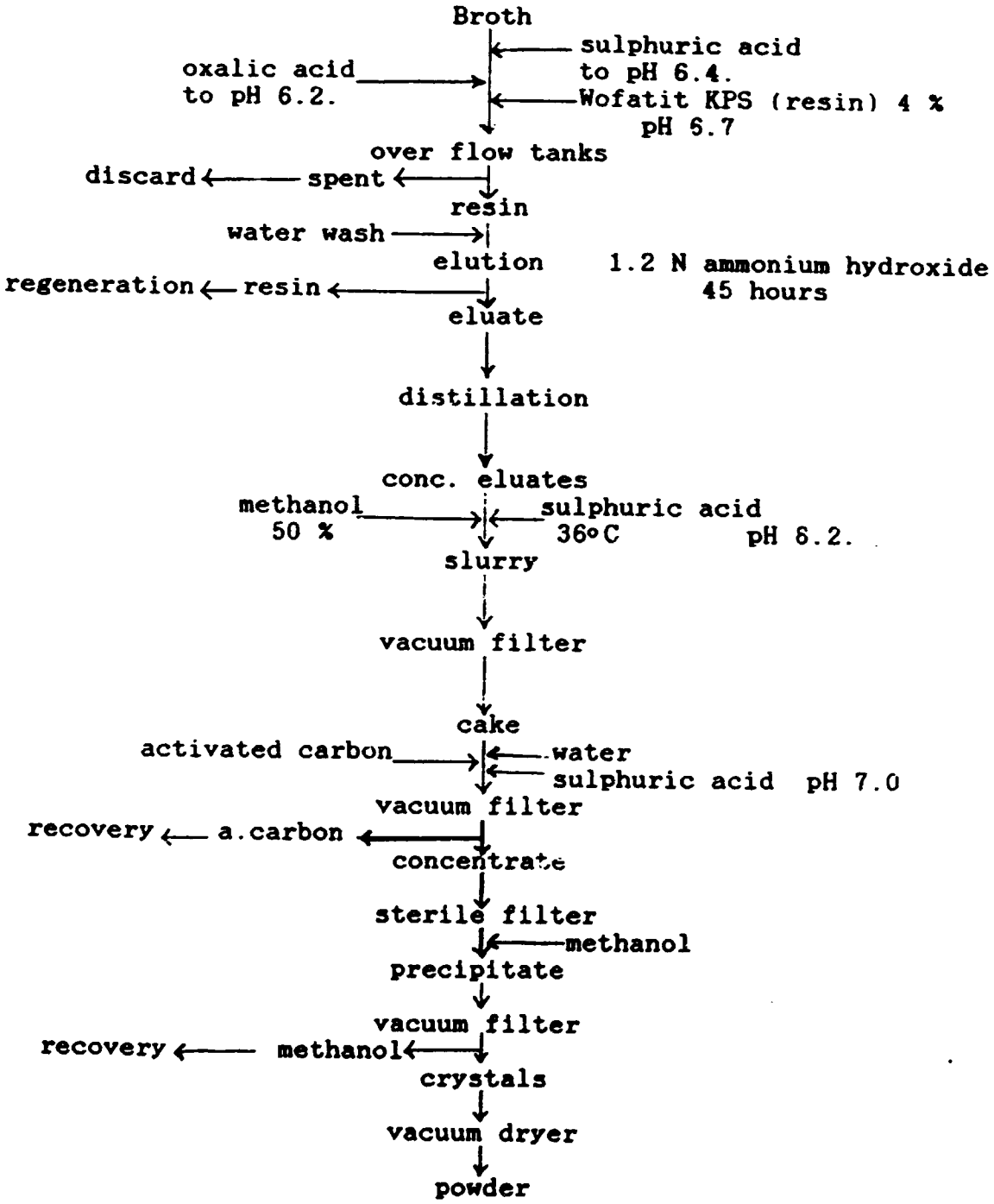
4.9.2.A crystallisation tank 500 lts capacity is in the sterile area. 98 % methanol, 7 times the volume of the solution is added to the vessel. The solution containing kanamycin is sprayed on the top slowly and under stirring for 30 minutes.

4.10. Filteration and drying.

4.10.1.The contents are taken through a small (20) SS open vacuum filteration unit. The mother liquor is collected in a tank tested and methanol is recovered.

4.10.2.Approximately 50 kg of wet kanamycin sulphate is removed and taken in a vacuum dryer at 37°C. After drying the lumps are ground and sieved to give uniform powder.

4.11. Flow sheet.



5. Rifampicin - Down stream processing.

5.1. Broth treatment and filteration.

5.1.1.Broth with potency of 3,500 u/ml and pH 6.8 is received in a carbon steel tank of 25 M^3 capacity. To 10 M^3 broth water is added along with zinc sulphate 3 - 4 %and pH is adjusted to 4.6 -4.7. with 4 M^3 more water addition. The contents are stirred for 30 minutes. Then pH is increased to 8.2 - 8.4 with 15 % sodium hydroxide addition.

5.1.2.Broth is then taken in small portion through 1 M^3 M.S. tank to 2 cast iron filter presses. Unlike other filter presses these have mechanical closing device. The filter presses are 40 sq. meters each. It takes 24 hours to filter 16 M^3. The filter presses get choked every 3 hours and need cleaning. The filterate is taken to 2.0 - 2.5 M^3 storage tanks.

5.2. Extraction.

There are 3 small Rossia extractors in the first floor. The broth filtrate is sent under pressure to the extractor through a rotameter. Filterate flow rate of 1 M^3/hr is maintained. Butyl acetate is fed in to the extractor from a tank at the rate of 330 lt/hr. Sulphuric acid is fed to ,the extractor to maintain pH at 2.0. 95 % of potency is recovered. For 5 M^3 broth filtrate 1,650 lts of extract is recovered.Potency is around 6000 u/ml.

5.3 Buffer treatment.

The extract is taken to two 2.5 M^3 SS tanks with conical taper at the bottom. Phosphate buffer 300 lts is added under stirring. The operation is carried out at room temperature and after stirring the liquid is allowed to stand for an hour. The butyl acetate is recovered for reuse.

5.4. Precipitation and filteration.

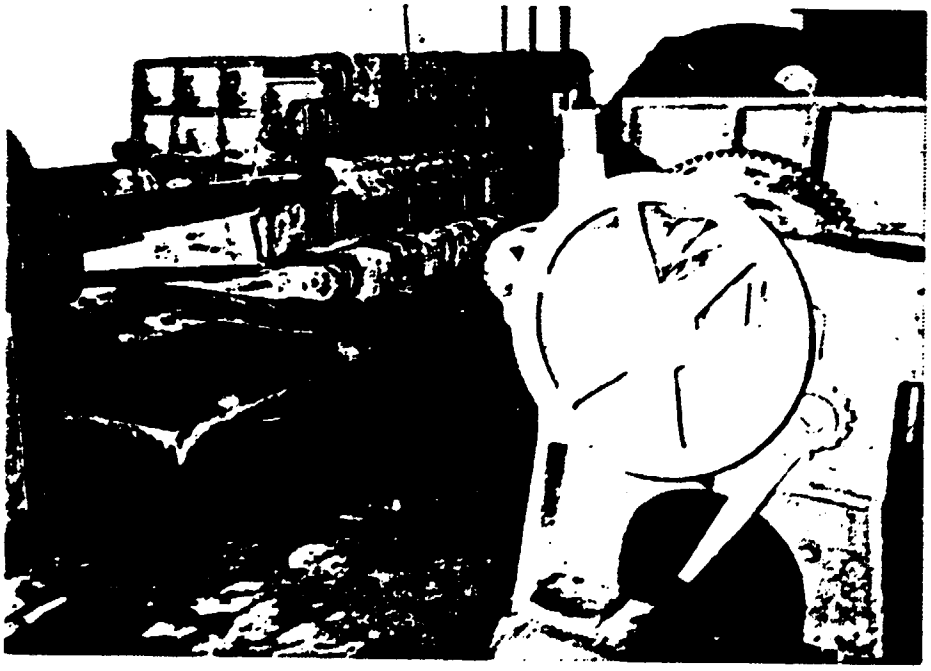
5.4.1.The water layer from the bottom is taken to 2 M^3 SS tank. Ammonium persulphate the rate of 0.9 kg/milliard is added to this. The contents are stirred and cooled with brine in jacket to 8 - 10°C. Rifamycin O precipitates.

5.4.2.The precipitate is run through a basket centrifuge or an open vacuum filter. The overall yield is 90 kg/10M^3 batch.

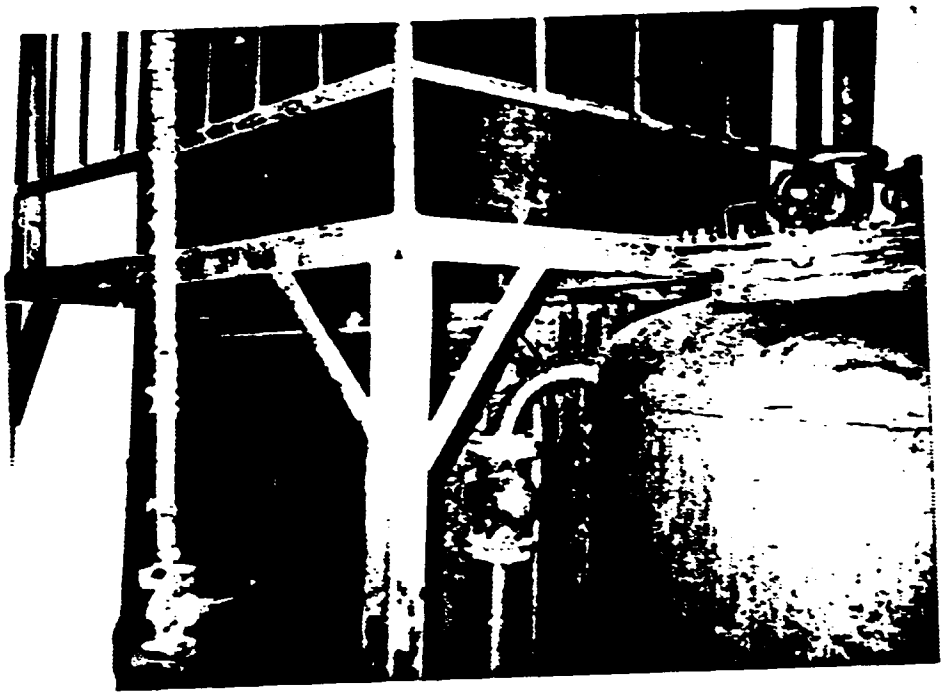
5.5. Recrystalisation and filteration.

5.5.1.The cake is taken in 0.5 M^3 SS tank and 150 lts of methanol is added and stirred. This is carried out at room temperature for 16 hours. The contents are recentrifuged and the crystals are recovered. The crystals are washed 5 - 6 times with methanol and about 35 kg cake is obtained.

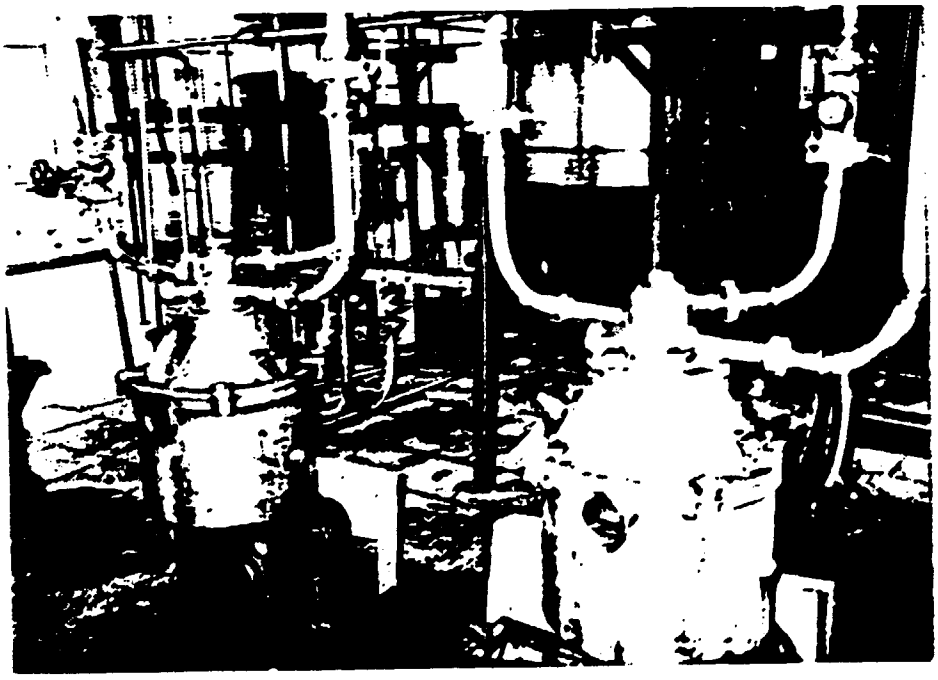
Rifampicin-Broth receiving tank



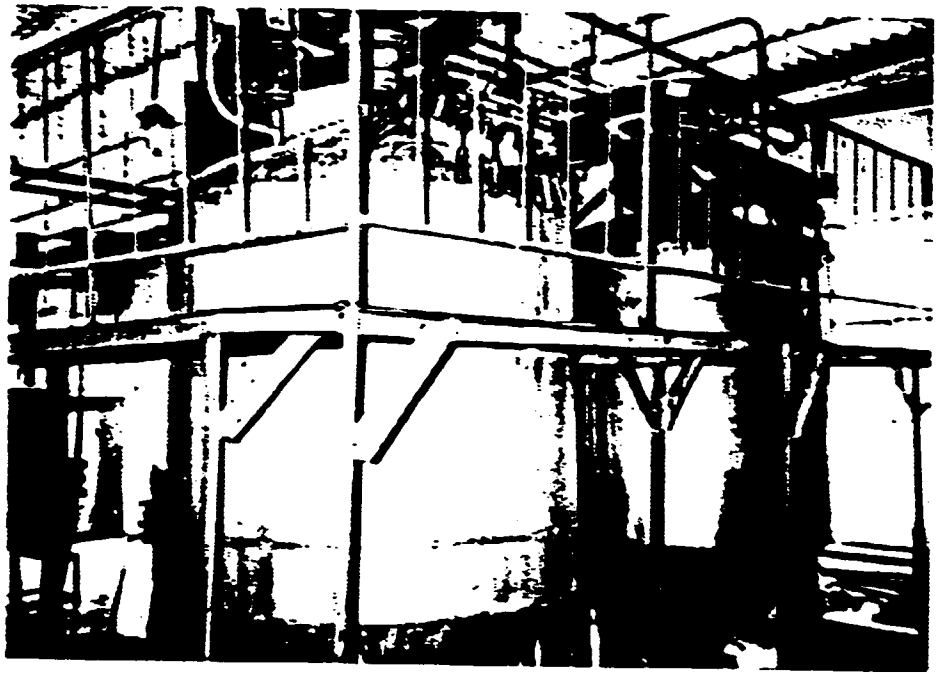
Rifampicin-filter press



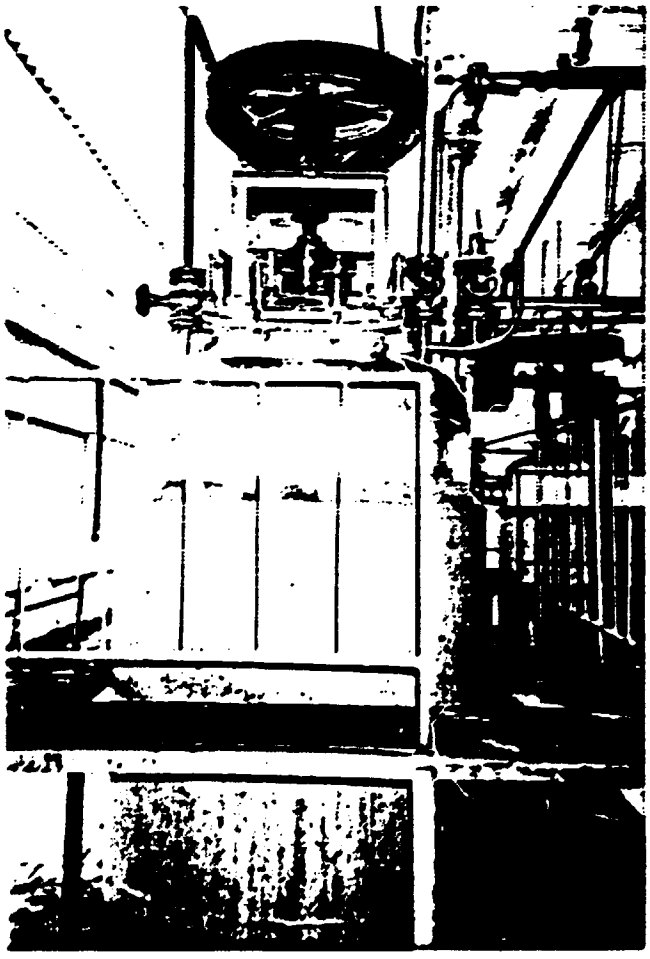
Rifampicin-Filtrate receiving tank



Rifampicin-Extractors

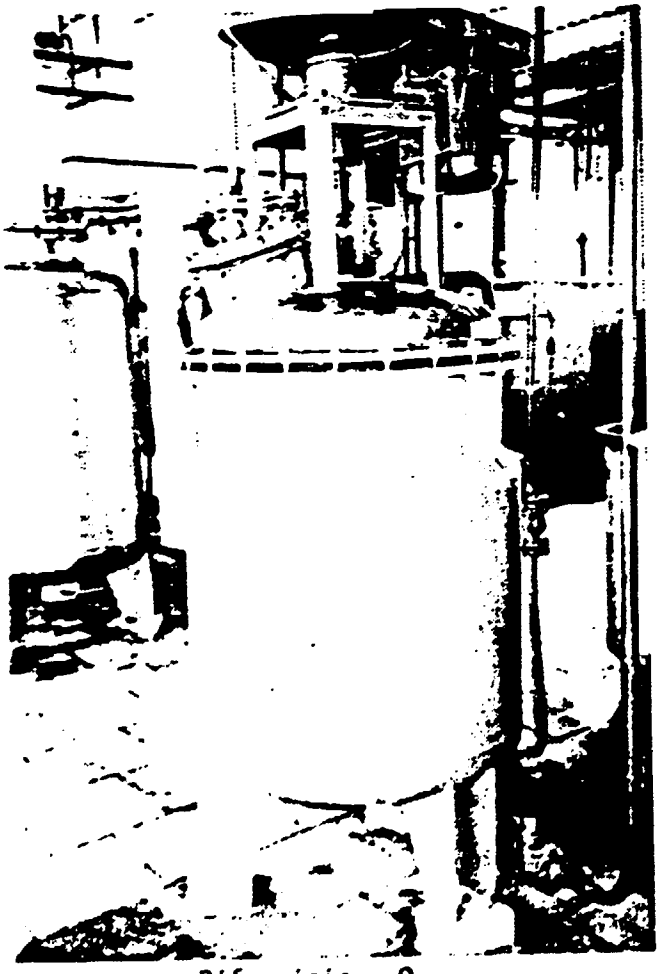


Rifampicin-extract (buffer)



Extract Treatment

Rifampicin-centrifuge



Rifampicin O
crystallization

5.6. Rifamycin O Conversion.

5.6.1.The cake is added to the same tank as above and 400 lts of methanol is added along with 0.08 N nitric acid. The contents are stirred for 8 hours. The conversion is checked by silicagel chromatography. The solution is filtered through a vacuum filter to remove the extranedus material.

5.6.2.The solution is taken in 2 M^3 SS tank and 1200 lts of water is added to it. Temperature is maintained at 18 - 20°C. The crystallisation is complete in 4 hours time. Crystals are filtered in vacuum filter.

5.6.3.The crystals are dried in vacum dryer at 50°C for 20 hours to obtain 20 kg.

5.7. Crystallisation and purification.

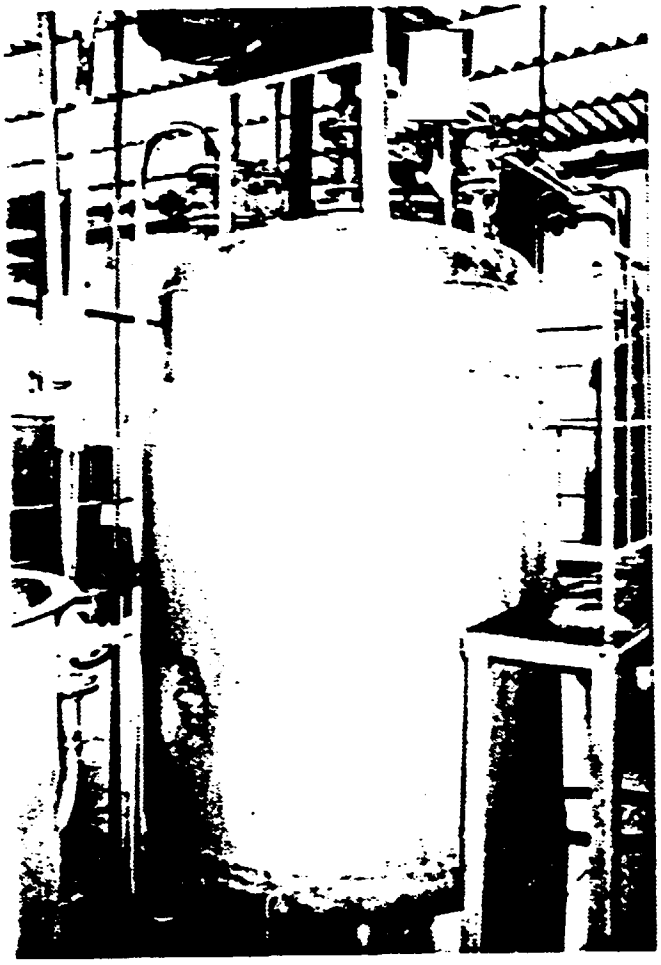
5.7.1.In the 400 lts SS tank the crystals are added on to 60 lts of iso-propyl alcohol. The contents are stirred and hot water is passed through the jacket to keep the contents at 60°C. After 8 hours the temperature is reduced to 10°C with brine circulation in the jacket. The crystals are now centrifuged, washed with iso-propyl alcohol and dried in the dryer. The yield now is 12 kg of crystals.

5.8. Treatment of crystals and conversion.

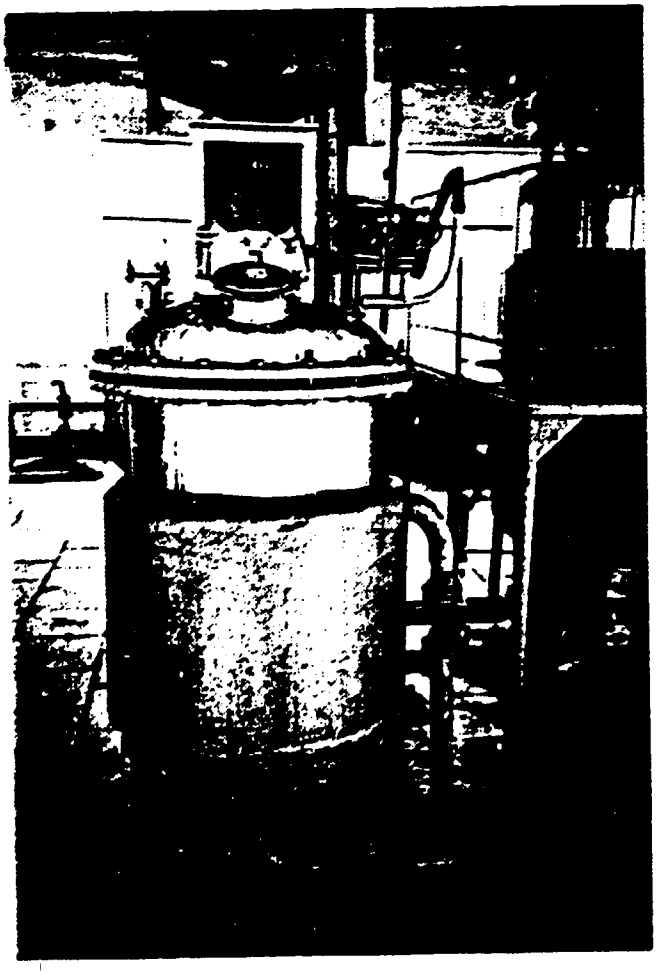
5.8.1.To the crystals glacial acetic acid 25 lts and tertiary butly azomethane 8 kg are added.Now the pH comes to 5.2 - 5.8. Temperature is raised to 50°C and the contents are stirred for 18 hours. Again the contents are transferred to 2 M^3 SS tank and 10 times the amount water is aded approximately 120 lts. The contents are cooled to 15°C. The crystallized material is centrifuged and approximately 24 kg crystals are obtained.

5.9. Rifampicin conversion.

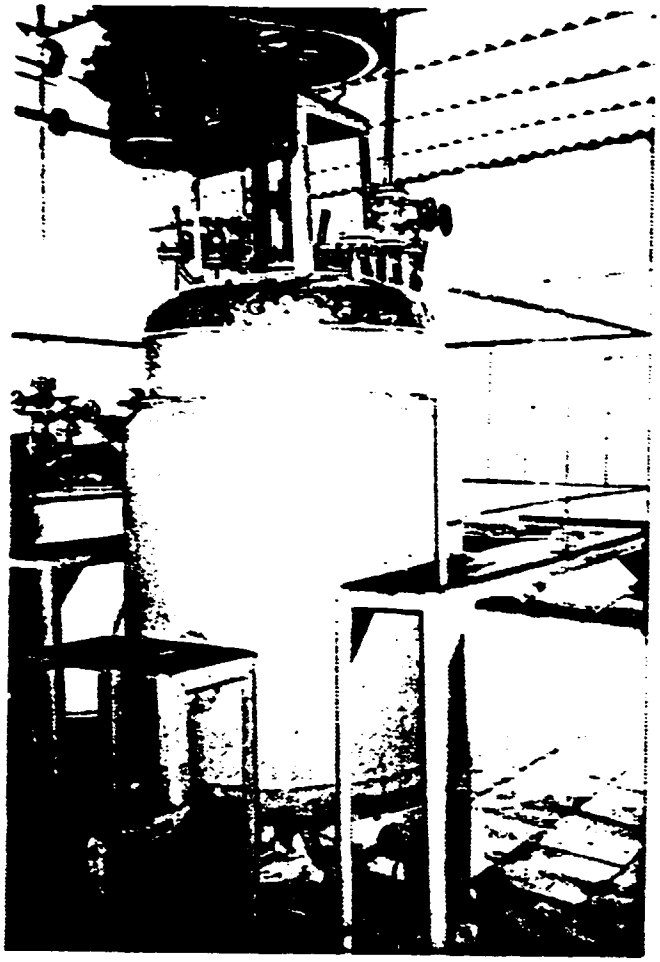
5.9.1.To the 24 kg crystals 59 lts of methanol is added in a 70 lts carbon steel tank kept aloof for this work. Temperature is raised to 60°C and stirred for 8 hours. With acetic acid pH is adjusted to 5.2 - 5.8 and cooled to 40°C. To the contents distilled water 30 lts is added slowly in 2 - 3 hours time. Crystallisation occurs and the temperature is reduced to 10°C. The crystals are centrifuged and washed with methanol water (70 : 30) The crystals are dried in dryer with steam in pipe at 60°C. The final product 10 kg works out to 30 % recovery.



Rifamycin G Conversion



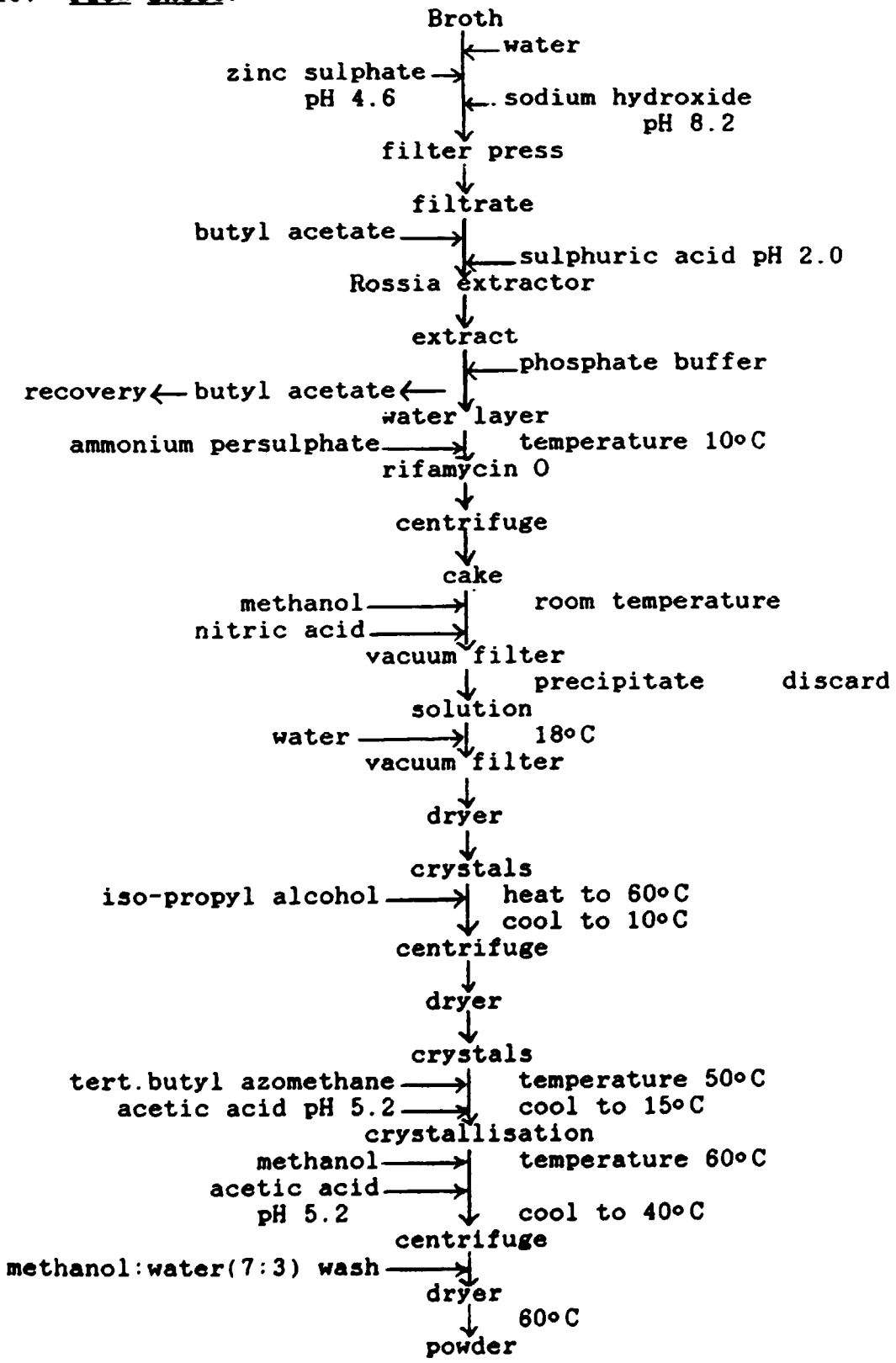
Re-crystallization



Rifamycin S
Crystallization

Rifampicin dryer

5.10. Flow sheet.



6.0 Suggestion for improvement.

6.1. Penicillin.

6.1.1. The filteration takes 8 hours for 10.5 M^3 through filter press, provision of rotary vacuum filter will lead to faster and better filteration.

6.1.2. Deemulsifier is inefficient, hence the filterate is heated to 70°C for coagulation. This leads to 8 -10 % loss. Substitution of better deemulsifier will lead to avoiding this heating step.

6.1.3. As the coagulates are again centrifuged for their removal this again leads to delay and steps 6.1.2. and 6.1.3. can be avoided with a better deemulsifier.

6.1.4. The extractor (Westfalia) is run at 2 M^3/hr which can also be improved upon. provision for higher capacity extractor will lead to better and faster extraction.

6.1.5. The buffer extraction is done in a tank with a stirrer which can create a lot of emulsion. This should be carried out with an extractor.

6.1.6. The centrifuged material need not be taken in a vessel and washed with butanol and recentrifuged. The cake on the centrifuge itself can be washed with butanol several times. This will lead to cutting down the loss in these extra steps.

6.1.7. It is worthwhile to acquire a rotary drum dryer instead of the tray dryer where uniform powder can be obtained.

6.1.8. A proper material balance of each and every step is necessary to improve purification efficiency.

6.2. Oxytetracycline.

6.2.1. Along with heavy metal precipitation floculating agent should also be added to the broth.

6.2.2. The broth should be chilled to 14°C to avoid anymore unwanted contaminations as the time taken for filteration is very long.

6.2.3. Provision of pre-coat filter with 10 M^3/hr capacity will eleminate acute filteration problems.

6.2.4. Precipitation material balance has to be worked out clearly.

6.2.5. Filter press for precipitate filteration has to be changed to SS or epoxycoated filter press of higer capacity 50 - 70 kg/batch,

6.2.6. Instead of spreading the filterate in 10 different vessels of smaller capacity by increasing the capacity of filteration 10 M^3 can be treated in a single vessel to avoid spreading the loss in different vessels.

6.2.7. Overall efficiency of 65 - 70 % purification is due to the exess time taken for filteration and too many vessels for precipitation ofa single batch.

6.3. Kanamycin.

6.3.1 After the removal of heavy metals as oxalates the resin 4 % is added directly to the broth. After mixing thewhole broth and the resin it is allowed to overflow from one tank to another to collect the resin. This practise sems to be abnormal. The broth has to be filtered through a precoat filter or in its absence through the filter press and then allowed to pass through the resin for adsorption.

6.3.2. Kanamycin A sulphate which is precipitated with methanol and sulphuric acid can be repeated to increase the yield.

6.3.3. In most of the cases the decolourisation step is not required. But here this extra step leads to some loss during purification.

6.3.4. As the overall efficiency is claimed approximately 60 %, loss during resin overflow, elution and concentration seem to be higher than what is claimed. Accurate material balance of every step is required.

6.4. Rifampicin.

6.4.1. The efficiency of filteration has to be improved. There are only 2 filter presses of 40 sq. mt. each. Either the capacity has to be increased to 80 sq. mt., 2 numbers or a precoat filter of 10 M^3/hour capacitiy is the necessity.

6.4.2. Conversion of Rifamycin B to Rifamycin O.
The former is insoluble in water as free acid and the latter is sparingly soluble in water. The filtrate can be extracted with butyl acetate or chloroform, followed by phosphate buffer. This should be reextracted with ethyl acetate at pH 2.0, followed by phosphate buffer at pH 8.0. Addition of sodium persulphate precipitates Rifamycin O.

6.4.3. The extra one step extraction improves the purification and the method used at Sunchon with ammonium persulphate can be followed.

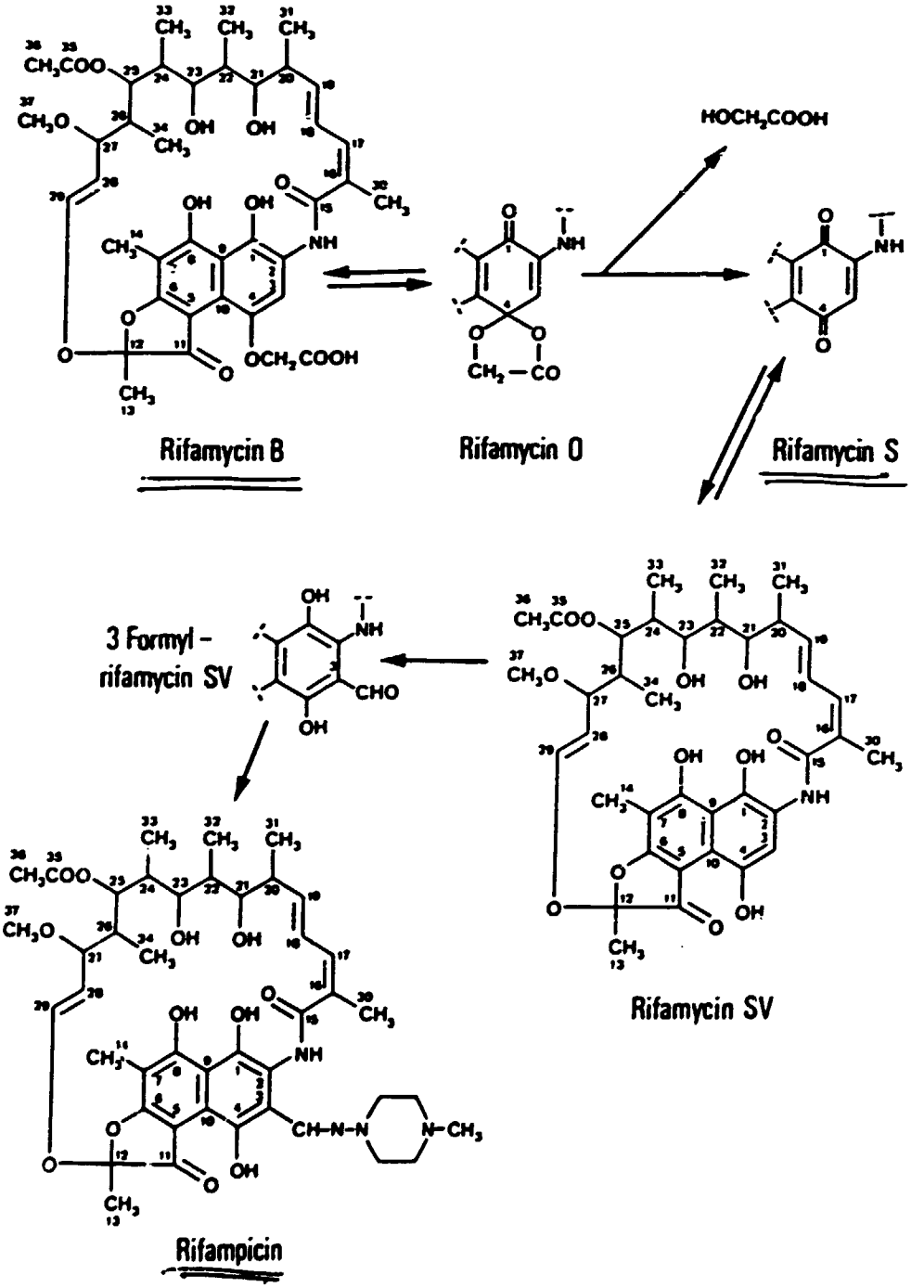
6.4.4. Rifamycin O is hydrolysed to Rifamycin S with sulphuric acid in tetrahydrofuran. The method used at Sunchon with methanol and nitric acid may also lead to nitration during hydrolysis unless it is properly controlled.

6.4.5. Further conversion of Rifamycin S to Rifamycin SV at Sunshon is not very clear.

6.4.6. One method is diluting Rifamycin S with water, extracting with chloroform, concentrating the extract, diluting with ethanol and distilling it. The crystals obtained are dissolved in methanol and by adding aqueous solution of sodium ascorbate Rifamycin SV is obtained. After cleaning the solution through filter press it can be left to crystallize by addition of sodium persulphate.

6.4.7. In the second method Rifamycin S is treated with secondary amine and formaldehyde. The base formed is oxidised with alkyl-nitrite or leadtetraacetate in solvent.
By treating Rifamycin S with formaldehyde and a primary lower alkyl amine in the presence of an oxidising agent like manganese dioxide will lead to 3-formyl Rifamycin SV.

6.4.8. The 3-formyl Rifamycin SV can be converted to Rifampicin by treating with 1 amino-4 methyl-piperazine.


HOCH₂COOH
Rifamycin B
Rifamycin O
Rifamycin S
3 Formyl - rifamycin SV
Rifamycin SV
Rifampicin

7. Equipment.

As already indicated in Report on Fermentation of Antibiotics SI/DRK/88/802-11-01, the general condition of the plant is poor.

The following equipment are needed for immediate upgradation of the plant for efficient purification.

7.1. Liquid - liquid extractor - capacity 10 M^3/hour - Potbielnik or Westfalia ....1 number.

7.2. Rotary vacuum filter for penicillin G - capacity 10 M^3/hour - Dorr Oliver or Alfalaval.

7.3. Precoat filter or 80 sq.mt filter press SS 304, capacity 10 M^3/hour ....2 numbers.

7.4. Vacuum distillation units, capacity 2 M^3/hour ....2 numbers.