

ISMA* Technical Conference

Sandefjord, Norway
8-11 September 1970

**In 1982, the name of the International Superphosphate Manufacturers' Associations (ISMA) was changed to International Fertilizer Industry Association (IFA).*

THE TYPPI OY SOLVENT EXTRACTION
PROCESS FOR NITROPHOSPHATES

By :

N. Lounama
O. Numminen
L. Niinimäki.

Typpi Oy
Finland.

CONTENTS

	Page
1. INTRODUCTION	2
2. THE TYPPI OY FERTILISER PROCESS	2
a) Development of Typpi Oy's solvent extraction method	2
b) Patent protection for the Typpi Oy process	2
c) Other fertiliser processes based on solvent extraction	3
d) Flow sheet of the process	3
e) Selection of solvent	4
f) A more detailed examination of the process	5
g) Quality of products	6
h) Consumption figures and investment costs	7
3. SUMMARY	8
REFERENCES	8

1. INTRODUCTION

During the past few years there has been a growing interest in the nitrophosphate processes. The reason has been the rising prices of sulphur and the fall of nitric acid prices due to the start-up of large new ammonia plants. Changes in raw material prices and development of production methods have been so considerable that the nitrophosphate methods are growing more popular even in the United States. Generally the share of the fertiliser market occupied by compound fertilisers is increasing. There is also a trend towards compound fertilisers with higher water solubility and higher grades.

Fig. 1 shows an example of the development of compound fertiliser nutrient content in the United States.

The increasing share of compound fertilisers and the rise in their nutrient content can be seen also in Finland. The rise of nutrient content of these fertilisers will continue during the fertiliser year 1969/1970.

2. THE TYPPI OY FERTILISER PROCESS

a) Development of Typpi Oy's solvent extraction method

The trends mentioned above have also been followed in Typpi Oy, where the original PEC-process was replaced by the Odda-process in 1962. Entirely new development prospects were opened up in 1963 with Professor Veijola's thoughts about the manufacture of nitrophosphates with solvent extraction. After preliminary experiments the study was passed over to Typpi Oy in 1964. After completing the laboratory research, a pilot plant was built in 1968. Its capacity is 400 kilos apatite/h. The pilot plant consists of solvent extraction, neutralisation and solvent recovery. The nitrophosphate solution comes from the compound fertiliser plant, which also processes the products of the pilot plant.

Typpi Oy is also working with other solvent extraction processes: we have five different solvent extraction processes in our rare earth plant and we have sold extraction know-how to other companies.

b) Patent protection for the Typpi Oy process

At an early stage of development we found the solvent extraction process combined with neutralisation to be competitive as a production method for nitrophosphates. We have applied for patents in many countries. Some of the patents have already been granted and some are still under consideration. Typpi

Oy's extraction method is patented, for example in England under Br. pat. 1129793 and Br. pat. 1125720.

c) Other fertiliser processes based on solvent extraction

In the inorganic field the solvent extraction technique has until recently mainly been used for producing valuable metals. The first time the solvent extraction technique was used on an industrial scale for the production of a cheap bulk product was in the manufacture of phosphoric acid (2) by Israel Mining Industries. In the IMI-process raw phosphate is dissolved in hydrochloric acid and the phosphoric and hydrochloric acid extracted with an organic solvent. Solvent and acids are separated by distillation. IMI has also developed some other solvent extraction processes : among these there is one for manufacturing potassium nitrate (3) from nitric acid and potassium chloride and one for purification of phosphoric acid (4). Solvent extraction has been suggested for the production of nitrophosphates (5, 6) and monoammonium phosphate (7), but as far as we know they have not yet been applied on an industrial scale.

d) Flow sheet of the process

Fig. 4 shows the flow sheet of the Typpi Oy fertiliser process.

Apatite is dissolved in nitric acid and the crude insoluble is separated. Phosphate solution is fed into the extractor, where phosphoric acid and nitric acid transfer to the C 4-5 alcohol used as solvent. The solvent leaving the extraction section is washed with ammonium nitrate in order to reduce the amount of calcium transferred. The raffinate leaving the extractor contains calcium ammonium nitrate and nearly all of the impurities of the raw phosphate. The organic extract contains the acids but almost no calcium or other impurities.

The organic phase is neutralised with ammonia and settled into two layers : a heavy slurry of ammonium nitrate, ammonium phosphate, and water, and a light, nearly pure solvent. The solvent is returned through cooling to the extractor, and the NP-slurry, which contains some solvent, passes to solvent recovery. Solvent recovery is carried out by distillation and the distillate is passed to solvent circulation. NP-slurry is evaporated and used for NP- or NPK-fertiliser production. The nutrient content of NP is 26:26:0, that of NPK 18:18:18, and the water solubility of phosphorus is over 98%. The raffinate from the extractor is neutralised and the dissolved solvent recovered by distilla-

tion. The calcium nitrate solution, which does not contain solvent, can be used for producing nitrate of lime, or converted with carbon dioxide and ammonia to ammonium nitrate. The ammonium nitrate solution can be used for the manufacture of either ammonium nitrate or calcium ammonium nitrate.

e) Selection of solvent

Selection of solvent for nitrophosphate extraction process is an important task. The most frequently used solvents are n-butanol and isobutanol. These alcohols may react violently with nitric acid if they are mixed in an unfavourable ratio and at too high a temperature. Typpi Oy has also examined these alcohols but in this connection we would suggest a new, technically feasible choice. If tertiary amyl alcohol is chosen, the process is safe even under extreme conditions. Another important fact is that the solvent is not easily oxidated.

The most important properties of tertiary amyl alcohol are as follows (8) :

Amyl alcohol (tertiary)
Amylene hydrate, dimethyl ethylcarbinol
2-methyl-butanol-2

Physical properties :

A colourless liquid, fluid at ordinary temperatures, tertiary amyl alcohol will solidify in cold weather to a mass of hygroscopic acicular crystals. It has a camphoraceous odour and a pungent burning taste.

Molecular weight	88.15
Boiling point at 760 mm Hg	101.8° C
Melting point	- 11.9° C
Flash point (closed up)	70° F (21° C)
Specific gravity at 20°/40° C	0.809
Refraction index at 20° C	1.4052
Specific heat at 20° C	0.753 cal/g
Coefficient of expansion	0.00133
Latent heat of evaporation	106.2 cal/g
Viscosity at 10° C	3.70 cp
at 63° C	0.99 cp
Solubility of alcohol in water at 10° C	20.5 per cent v/v
" " " " " " " "	30° C 14.0 " " "

Solubility of alcohol in water at 50° C	10.6	per cent v/v
" " " " " " 70° C	8.7	" " "
Solubility of water in alcohol at 10° C	17.6	per cent v/v
" " " " " " 30° C	17.7	" " "
" " " " " " 50° C	17.8	" " "
" " " " " " 70° C	17.9	" " "

f) A more detailed examination of the process

The flow sheet of the Typpi Oy process is shown in Fig. 5.

The extraction is in eight stages and the removal of calcium from the extract in two stages.

The extraction of phosphate solution is technically difficult to fulfil, because of the insolubles and surfactants present. If the feed of nitric acid into the extractor is not correct, monocalcium phosphate will precipitate thus blocking the extractor and decreasing the yield. Typpi Oy has solved these problems with an extractor of new construction, for which patents are pending.

The organic solvent leaving the extraction section contains, besides phosphoric acid and nitric acid, also calcium, which is removed with a 50% ammonium nitrate solution. The ammonium nitrate is returned from conversion. In this way a very pure mixture of ammonium nitrate and ammonium phosphate will be gained with neutralisation.

To prevent solvent losses, the method of neutralisation of the extract phase is very important. Solvent separation after neutralisation can be carried out nearly to completion. Solvent content of the separated NP-slurry is less than 1%. Solvent recovery is done by evaporation.

Calcium ammonium nitrate solution coming from extraction is neutralised and the solvent recovered by distillation.

Calcium nitrate solution has been converted at Typpi Oy's conversion plant.

The solvent flow of the extraction process (Fig. 6) shows an important point of the technique : the bulk, over 99%, of circulating solvent can be separated mechanically. Less than 1% of the solvent has to be recovered by distillation.

A considerable part of Typpi Oy's research work on this

process has been to determine and minimize solvent losses. The quantitative determination of losses as small as these requires accurate analytical methods.

g) Quality of products

Typpi Oy's research work is mainly based on Kola-apatite and 56 to 60% nitric acid. Experiments have also been carried out with some low grade domestic apatites and the results of these experiments have been good. An important advantage of the solvent extraction route is the fact that raw phosphates containing impurities can also be used as raw materials.

When using Kola-apatite as raw material the products of the Typpi Oy process are as follows :

Table 1

Analyses of Kola-apatite and products

	Kola-apatite %	NP 26:26 %	Ammonium nitrate %
E N		26.0	34.8
NH ₄ -N		16.1	17.4
NO ₃ -N		9.9	17.4
E P ₂ O ₅	38.7	26.0	0.001
WS P ₂ O ₅		25.6	
CaO	52.6	0.17	0.1
F	3.2	0.10	0.025
SiO ₂	2.5	0.12	-
Fe ₂ O ₃	0.50	0.002	<0.0004
Al ₂ O ₃	1.1	<0.005	<0.007
MgO	<0.1	0.0008	0.0001
Na ₂ O	0.47	0.0004	0.09
K ₂ O	0.27	0.0002	0.08
CO ₂	0.10	-	-
Org.	0.10	-	-

The high nutrient content and the good water solubility of phosphorus can be seen from the NP-product analyses. The product has a nutrient content very close to the highest

theoretical content which can be reached in fertilisers with an N, P_2O_5 -ratio of unity, when ammonia, nitric acid and phosphoric acid are used as raw materials.

The N, P_2O_5 -ratio of the product in the Typpi Oy process is unity or greater, due to coextraction of nitric acid with phosphoric acid.

For NPK-products potassium can be added as usual.

h) Consumption figures and investment costs

The following consumption figures are based on the experiments carried out in our pilot plant :

Table 3

Consumption figures for the Typpi Oy fertiliser process
Produced : 1 ton NPK + 0.6 tons of 80% ammonium nitrate solution (calculated at 100%).

Kola-apatite	0.467 tons
Nitric acid 100%	0.814 "
Ammonia	0.262 "
Potassium salt (60% K_2O) ..	0.300 "
Carbon dioxide	0.165 "
Steam 7.5 ata	0.225 "
Steam 2.5 ata	0.217 "
Electricity	50 kWh
Fuel oil	30 kilos
Cooling water	32 m ³
Process water	0.2 m ³
Solvent	2 kilos

The investment costs for a plant with a production capacity of 430 tons NPK 18:18:18 and 250 tons of 80% ammonium nitrate solution (calculated at 100%) per day have been estimated to be 4.0 million U.S. dollars.

3. SUMMARY

The Typpi Oy process for compound fertilisers is simple and gives NPK- and NP- products of excellent quality.

Last spring, after a detailed evaluation of alternative processes, Typpi Oy decided to build a compound fertiliser plant using the solvent extraction method. The capacity of the plant will be 500 tons of NPK per day.

* * * * *

REFERENCES

1. Hignett, T.A., Intern. Superphosphate Manufacturers' Association (London), Paper No. LSE/67/XVL (September 1967)
2. New processes for the production of phosphatic fertilisers using hydrochloric acid. United Nations, New York (1969)
3. Israel Mining Industries Institute for Research and Development, Division of New Fertilisers, Haifa, 1965, p. 12-15
4. Israel Mining Industries Institute for Research and Development, Israel Patent No. 21247 (1967)
5. Ionescu, E., British Patent No. 35944 (1966)
6. Stamicarbon N.V., British Patent No. 1049197 (1966)
7. Cousserans, G., Chim. Ind. Genie Chim. 100 (1968) : 9
1431-1436
8. Marsden, C. and Mann, S., Solvent Guide 2. ed., London 1963

DISCUSSION

Dr. N. LOUNAMAA (Typpi Oy, Finland) : One of the tasks of the fertiliser industry is to take the phosphate rock from its deposits, render it soluble and supply it to agriculture. This is so today and will be so in the future, notwithstanding those who speak about the destruction of the balance of nature.

Since, chemically speaking, phosphorus occurs only in one form in its deposits i.e. apatite-phosphorite, the objective is always to break the structure of the mineral and make the phosphorus soluble. As all of us know, this can be done by different methods. These methods have been developed into well-known processes and no useful purpose will be served by describing these processes here in any detail.

Certainly all these processes are more or less satisfactory. Under given circumstances, they economically provide plant-available phosphorus. However, methods which are even better, more effective and hence more economic can be developed.

Liquid-liquid extraction, together with other technological advances, came from the laboratory to the large scale production of inorganics when methods for the provision of atomic energy, based on uranium fuel, were developed. Nuclear fuel processes are still some of the main applications of liquid-liquid extraction. However pure uranium has a value of more than \$ 2,000 per ton and fertilisers less than \$ 100 per ton. This is a difference which, perhaps, excluded this separation method from the minds of the researchers investigating new methods of fertiliser production.

But let us go further and ask : if liquid-liquid extraction is an effective method of separation, why is it too expensive for cheaper materials ? Today it can be said, based on many years' experience, that the deciding factors are the costs of the chemicals, not the costs of the equipment. If the organic solvent used cannot be recovered and re-used or if chemicals, for example acids, are consumed in the stripping of the organic phase, then the total costs might be excessive in relation to the value of the product obtained.

Since the time of its first large scale application, the application of liquid-liquid extraction has been extended to cheaper materials. These materials include, among

others, rare-earths, zirconium, copper, nickel, cobalt, zinc, and also fertiliser-type material as first successfully demonstrated by Israel Mining Industries. However, a general use of liquid-liquid extraction for the production of materials with a price level such as that of fertilisers does not exist. In principle, however, there is nothing to prevent the use of this method in the fertiliser industry, provided that suitably selective extractants for the compounds essential for producing fertilisers can be found and the costs mentioned above are not prohibitive.

Slide 1 : This is to illustrate the basic principle of liquid-liquid extraction, as applied to the separation of calcium and phosphate and leading to the products calcium nitrate and ammonium phosphate.

Without attempting to describe all the different research phases or investigation periods during the years in which we have been working with this method, I would like to list the ten main points in the complete research programme (slide 2) :

1. The digestion of apatite and conditioning of the solution for extraction.
2. Construction of the extractors and other equipment.
3. The extraction itself including mixing and separation of phases.
4. Neutralisation of the organic solvent.
5. Mechanical separation of the phases and recovery of solvent by means of distillation.
6. Conversion of the calcium nitrate solution and NP solution to final products.
7. Quality of products and yields.
8. Solvent losses.
9. The safety of the process (organic solvent together with oxidants).
10. The economics of the process.

Every point has been the object of a thorough and careful investigation, both theoretically and experimentally. In retrospect it is hard to say which has been the most difficult point. Perhaps point 2 was that which required

the most creative work and resulted in new developments. Points 7 and 8 have been the main technical objectives, although it can be stated that the quality of products and yield have never been dominating difficulties during this project ; the same is also true as regards the safety problem.

The overall economics, in connection with solvent losses, was the main concern of this project during the first research period, but after solvent losses were controlled this point was no longer a critical one.

Slide 3 : And finally a picture from the pilot-plant. This is a 1:1 scale stage of our extractor.

The paper which has been distributed, and which I hope all of you have, describes our process and the products obtained. We do not consider that our process is so final that no improvements can be made, or that it has no sensitive points. But we believe that it has been developed to a degree which permits its technically and economically successful use under large scale conditions. This is also demonstrated by the fact that our company has, after careful comparison with other processes, decided to use this process in the new 500 tons/day plant for mixed fertilisers. This plant will be erected during the next two years.

Dr. J.H. KOPPER (B.A.S.F., Germany) : In this brief report on his work, Mr. LOUNAMAA has again summarised the objective of the phosphate industry : to separate the apatite calcium from the crude phosphate and to make the phosphorus available to plants.

Precipitation and, in the relevant case, separation of calcium in the sulphate form aside, the Odde process, in which the phosphate is attacked by nitric acid and the calcium separated out in the form of calcium nitrate tetrahydrate, has been proved economic. Certainly, the separation of calcium is incomplete. It is at this step that liquid-liquid extraction becomes relevant, since it could eliminate this disadvantage. The trend in the production of complex fertilisers to increasing concentration again underlines the importance of research of this type. The interest in this problem is shown clearly by the fact that two Companies, A.P.C. and Typpi Oy, are presenting papers at this Conference on the development of this process, and they are giving rise to lively discussions.

In our Company, we are using the Odde process on a large scale and we have already examined intensively the

presented extraction processes. From an economic point of view, we have found that the Typpi Oy-type processes were completely competitive. As the discussion of the APEX process has shown, the study of the question as to whether the extraction step can be carried out more economically than with the nitric attack process has not been very deep.

It necessitates the production of considerable quantities of $\text{Ca}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$, which should in practice be entirely transformed into ammonium nitrate, which implies the existence of a source of CO_2 .

The other peculiarity is the unitary character of the N:P₂O₅ ratio in the fertiliser, which, in the APEX process, in view of the manner in which the process is made to operate, should be avoided by a monoammonium phosphate, ammonium nitrate separation. The Typpi Oy process does not include this stage and, for this reason, can only give grades having an overall N:P₂O₅ 1:1 balance.

A comparison of investment costs and of the operation costs of the two processes is possible only with difficulty in view of the data presented.

In this connection I should like to put my first question to the authors : Does Typpi Oy foresee advantages in connection with the figures given for investment costs, energy and solvent consumption in the simplified process ?

We have not as yet pursued the extraction process beyond the laboratory stage, since we have come across considerable difficulties in using impure phosphates because of dissolved and undissolved organic and inorganic substances. This results in poor separation due to the organic impurities and in the precipitation of silica during the purification of the extract, and this can only be eliminated with the addition of NaF. Hence my second question.

Have you any experience on a semi-industrial scale with other phosphates, such as for example, Kola apatite, Moroccan phosphate or Florida pebble phosphate, and, in this case, have you resolved the difficulties in the extraction stage ?

In the extraction process, as in the Odda process, the technique of transforming calcium nitrate into ammonium nitrate and calcium carbonate is of decisive importance. Unlike with the Odda process a significant part of the impurities remain in the calcium nitrate solution in the case of the Typpi Oy process. My third question is therefore :

What effect do these impurities have on the precipitation and filtration of the CaCO_3 ? Is the calcium usable for the production of ammonium nitrate ?

It seems that the Typpi Oy process on the whole gives a higher concentration of N and P_2O_5 than the A.P.C. process. Hence my fourth question :

To what do you attribute these differences, and where are the principle losses in the Typpi Oy process ?

In our own research, we have considered, as in the APEX process, isobutanol as the most suitable solvent, especially as regards its price, as in the Oxo synthesis product. Typpi Oy recommends tertiary amyl alcohol which has relatively similiary properties. Hence my fifth and last question :

What are the particular advantages of the solvent chosen by Typpi Oy relative to isobutanol and would use of the latter present particular difficulties in your process ?

Mr. LOUNAMAA : I will answer questions 2 and 5, Mr. NUMMINEN questions 1, 3 and 4.

2. We have been mainly using Kola phosphate and our experience relates to this rock. However a rather low grade domestic apatite rock has also been tested and no special difficulties have been experienced. In this connection I would like to point out that in principle, it is one of the main advantages of the proposed method that even high contents of impurities such as iron, aluminium and other elements cannot cause disturbance because they are eliminated by extraction, i.e. they are all found in the calcium nitrate solution where they can easily be removed.

Apart from some small exploratory experiments with other phosphates of different origin, we have until now no particular experience as regards their behaviour in our process. It is however our intention to apply our process to all important phosphate raw materials in our pilot-plant, and I hope we shall have the occasion to report the results in the near future.

As regards the second part of your question concerning the difficulties in extraction, I suppose that this refers to raw materials and their quality and the difficulties in extraction caused by them. This might be a very critical point and, in fact at earlier stages of our work extensive trouble was experienced due to surfactants and foam-causing

elements resulting in poor separation of the phases in settling. However later developments totally eliminated these problems.

5. As mentioned in our paper we have tested several different solvents and three main arguments have been relevant : 1) the solvent must be suitable as an extractant for phosphoric acid, 2) the solvent must not give rise to dangerous conditions even if normal process conditions should be disturbed either by human error or by control equipment failure, 3) the cost of solvent must be reasonably economic. The second point was of prime importance when tertiary amyl alcohol was selected as a solvent.

Mr. NUMMINEN :

1. The different aims, different raw materials and end products of the APEX and Typpi Oy processes, do not allow a close comparison and I hope Dr. KOPPER will be satisfied with the explanation I shall give here. The outcome of an economic evaluation of a process may vary with the local conditions, price situation and the other factors forming the basis for the evaluation. In our case we compared the Typpi Oy extraction process and all other important nitrophosphate processes available at the time of this study, thus not including APEX process. We used the costing parameters valid in our company and had in mind the basic requirements of high nutrient content and high water solubility of the phosphate. This evaluation showed our extraction process to be fully and satisfactorily competitive. The raw materials form more than 80% of the production costs of the two main products, NPK and ammonium nitrate solution. The capital cost is about 10% and the other costs including wages, energy, other utilities and solvent account for less than 10%. Thus good yield factors are essential to the economy of the process.

A considerable part of the plant consists of conventional and well established technology which is tested and proven in both our own old Odda plant and numerous other production plants, especially in Europe. We have more than two years experience with solvent extraction in the pilot-plant and a successful scale-up of the extractor as shown in the slide Dr. LOUNAMAA presented. Thus we feel confident about our cost figures, both on the investment and the operating cost sides. The final answer will, of course, be given by the full scale plant when in production.

3. As Dr. KOPPER said, the impurities in the solution from digestion are found in the calcium nitrate solution. We

considered conversion of a solution containing impurities to be a difficult task. For this reason, we adopted a process proven on an industrial scale involving removal of the impurities prior to the conversion stage. The conversion can then be done with a clean solution giving pure calcium carbonate suitable for many purposes including calcium nitrate. The amount of actual waste product produced is rather small and a recovery of some of its components may be of economic interest.

4. The conversion process chosen contributes at the same time to a good total nitrogen yield, that is, in our calculations, 97.7% with Kola rock. The yield of phosphorus into the NP phase is, in the extraction step, about 99%. Total yield depends, of course, on the process combination chosen - in our case a yield of about 98.5% is expected. For the sake of clarity I should like to point out here that 18-18-18 mentioned in the paper is a grade name. The actual analysis is triple 17.8.

Mr. P. MORAILLON (Péchiney-Saint Gobain) :

1. In what way are the insolubles in the attack solution separated out and washed ?
2. What is the price of the solvent ?
3. What is the type of extractors used - total volume ?
4. Are plate columns used to recover the solvent from the NP slurry and from the aqueous raffinate ? What are the materials used ?
5. How is neutralisation effected to avoid loss of solvent ?
6. What is the water content of the NP slurry obtained by neutralisation ? How much of the solid phase (monoammonium phosphate crystals) does it contain ?
7. How is the filtration of CaCO_3 , obtained by conversion of $\text{Ca}(\text{NO}_3)_2$, effected, in spite of the presence of precipitated CaF_2 and SiO_2 ?
8. In the Kola phosphate used, the weight ratio of $\text{CaO}:\text{P}_2\text{O}_5$ is only equal to 1.36, whereas in most phosphates it is greater than 1.5. What is the influence of the $\text{CaO}:\text{P}_2\text{O}_5$ ratio on the minimum value of the $\text{N}:\text{P}_2\text{O}_5$ ratio in the fertiliser obtained ?
9. According to the figures given, the P_2O_5 yield would be 99.6%, the nitric nitrogen yield 96.0%, the ammonium

nitrogen yield 100.2%. Are these figures realistic ?

10. Do the investment costs indicated for the production of 430 t/day of 18-18-18 and 250 t/day of NH_4NO_3 in 80% solution include the granulation of the NPK fertiliser ?
11. Can the usual phosphates (Moroccan, Florida, Senegal, Togo) be used without calcination ?

Dr. LOUNAMAA :

1. The undissolved residue is separated by means of a decanter centrifuge which has been in use for our Odda process for a long time.
2. The catalogue price of the solvent is 30 cents/lb.
3. The extractor is a special design of our own and the volume will be confirmed when the scale-up will be made.
3. How is the solvent recovered from the NP slurry and what kind of distillation column is used ? This is also our special construction design, and not plate columns, and the material is stainless steel.
5. How do we effect the neutralisation to avoid solvent losses ? We simply introduce ammonia into the vessel.
6. The amount of water in the NP slurry after neutralisation and the amount contained in its solid phase is very much dependent on the water content of the acid used and on the neutralisation temperature.
7. Already answered by Mr. NUMMINEN.
8. Influence of Ca:P₂O₅ ratio on N:P₂O₅ ratio in the resulting fertiliser ? Of course the ratio in the fertiliser will be changed a little when the amount of calcium is higher in the raw material, but the main part of the nitrogen goes to the calcium nitrate solution so that the N:P₂O₅ ratio is always very small.

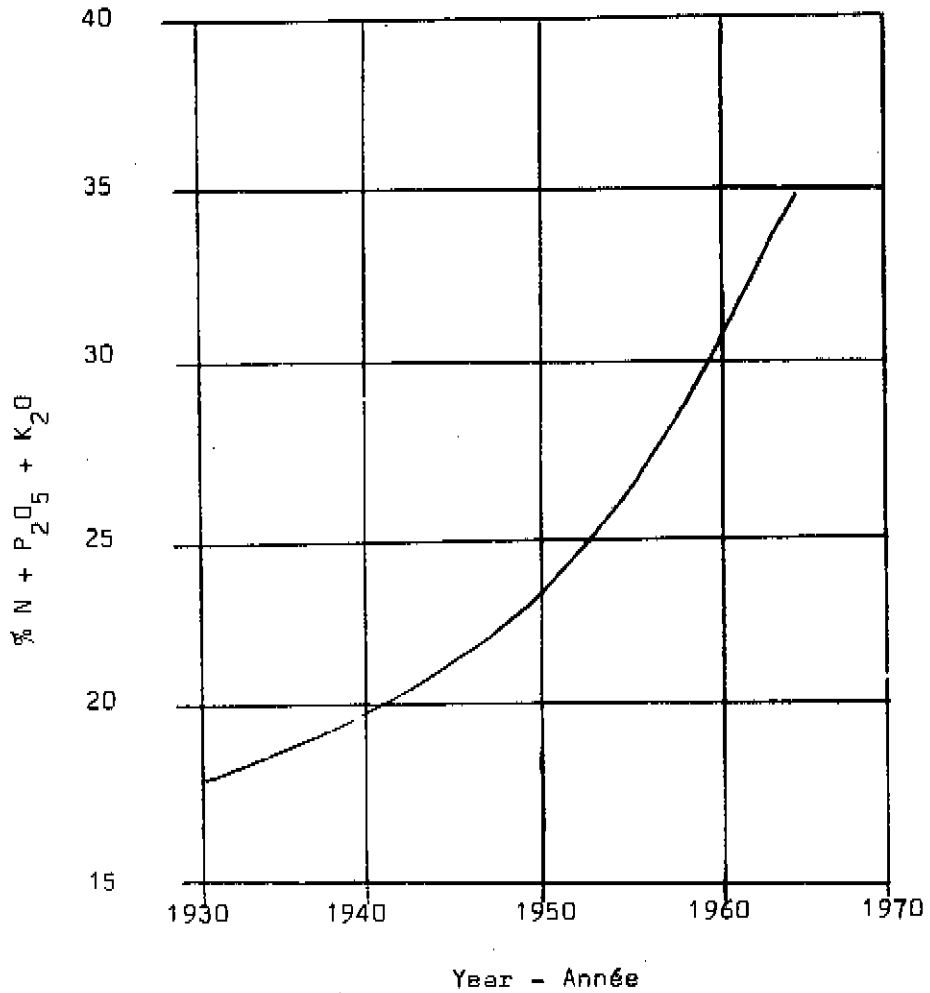
Mr. M. NOIRBENT (Kaltenbach, France) :

1. You have mentioned that you compared your process with other processes. What are the strong points, the specific qualities of your process, which have led you to prefer it to others which have been available to you and which have the advantage of longer industrial experience ? Was it

FIGURE I

PLANT NUTRIENT CONTENT OF COMPOUND
FERTILISERS IN THE UNITED STATES

EVOLUTION DE LA CONCENTRATION
DES ENGRAIS COMPOSES AUX
ETATS UNIS



Hignett, T.P., I.S.M.A. Ltd., LSE/67/XVII (Sept. 1967)

Figure 2

PLANT NUTRIENT CONTENT OF COMPOUND
FERTILISERS IN FINLAND

EVOLUTION DE LA CONCENTRATION DES
ENGRAIS COMPOSES EN FINLANDE

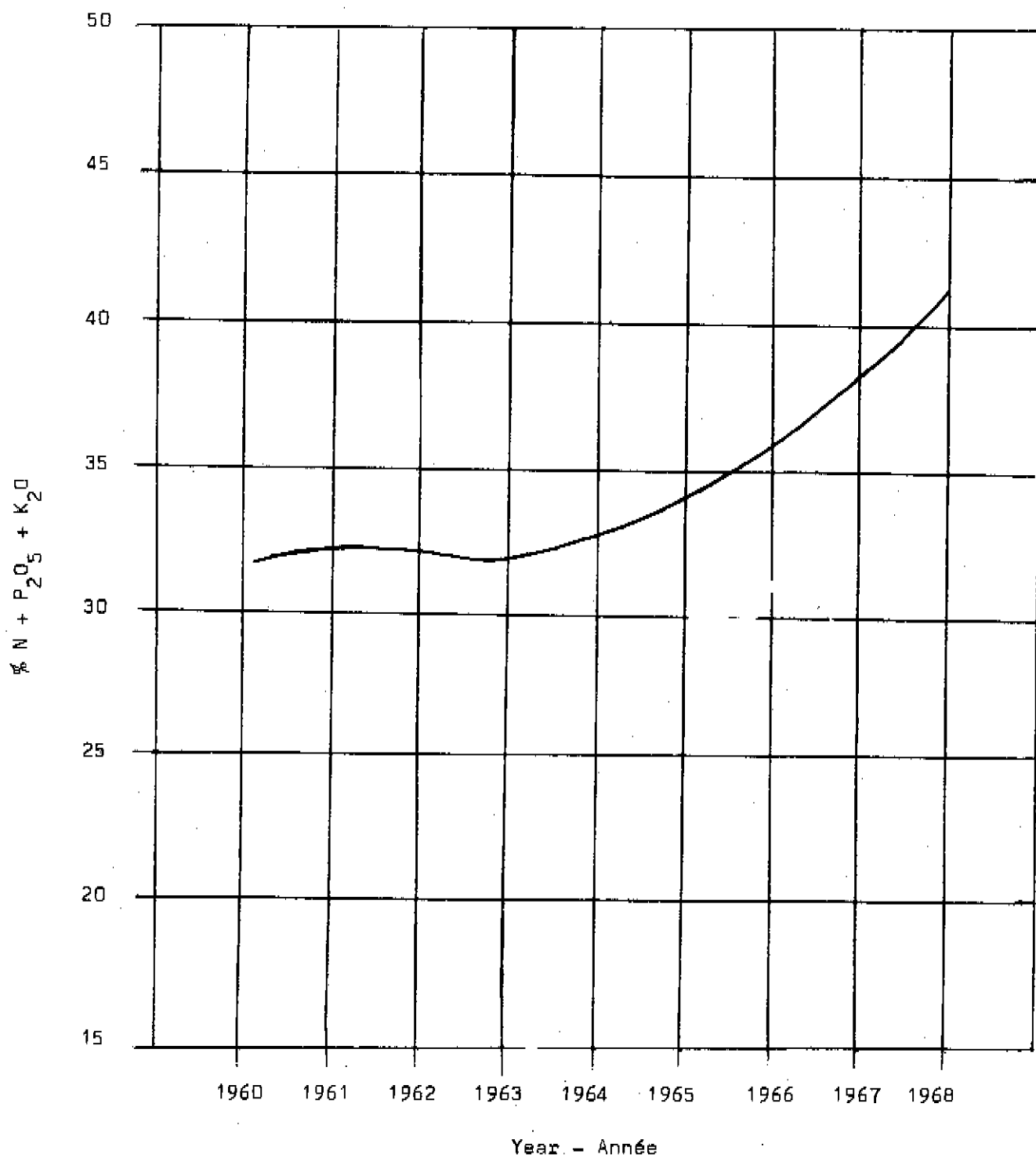


Figure 3

COMPOUND FERTILISERS' SHARE OF TOTAL
FERTILISER MARKET

PART DES ENGRAIS COMPOSES DANS L'ENSEMBLE
DU MARCHE DES ENGRAIS

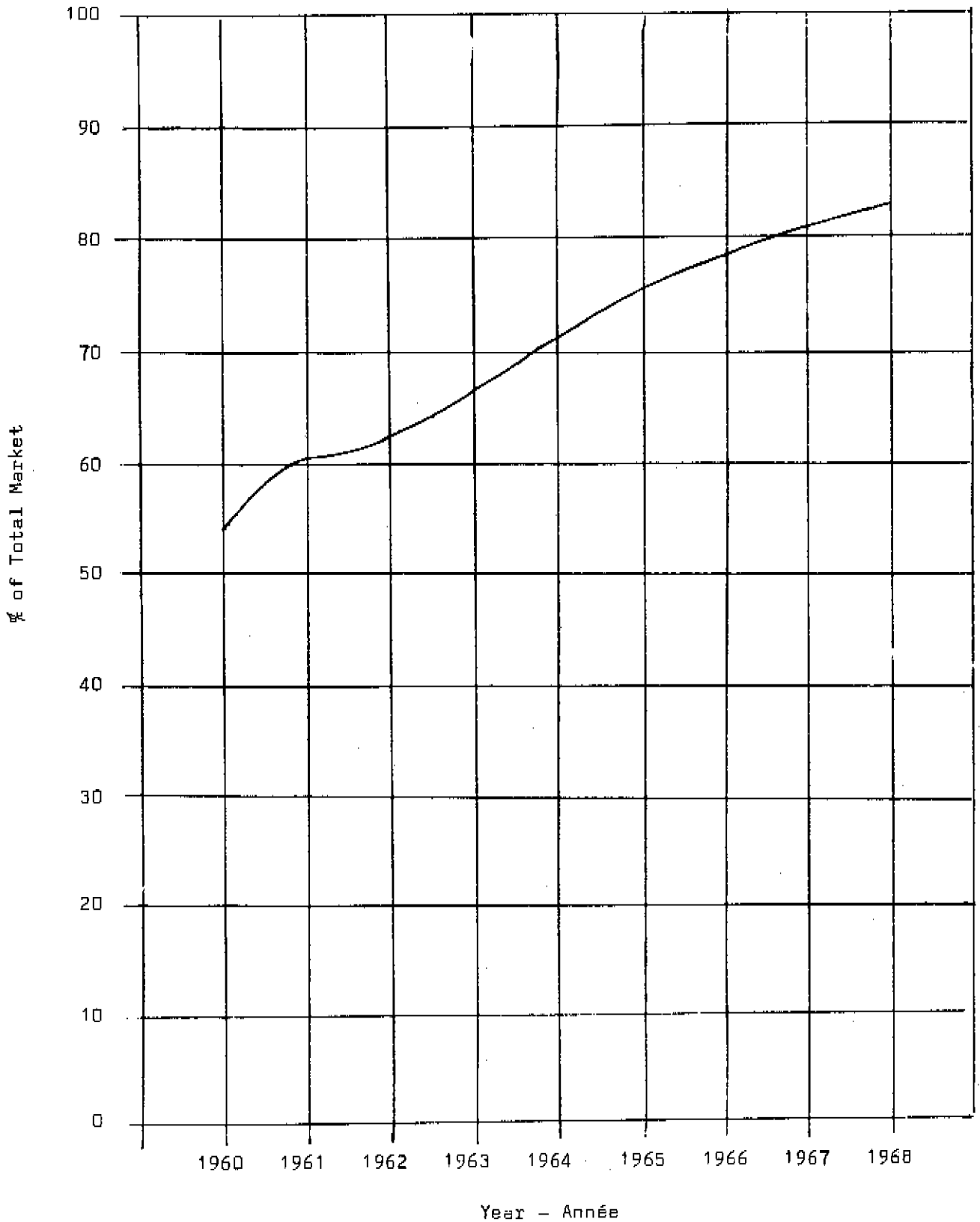
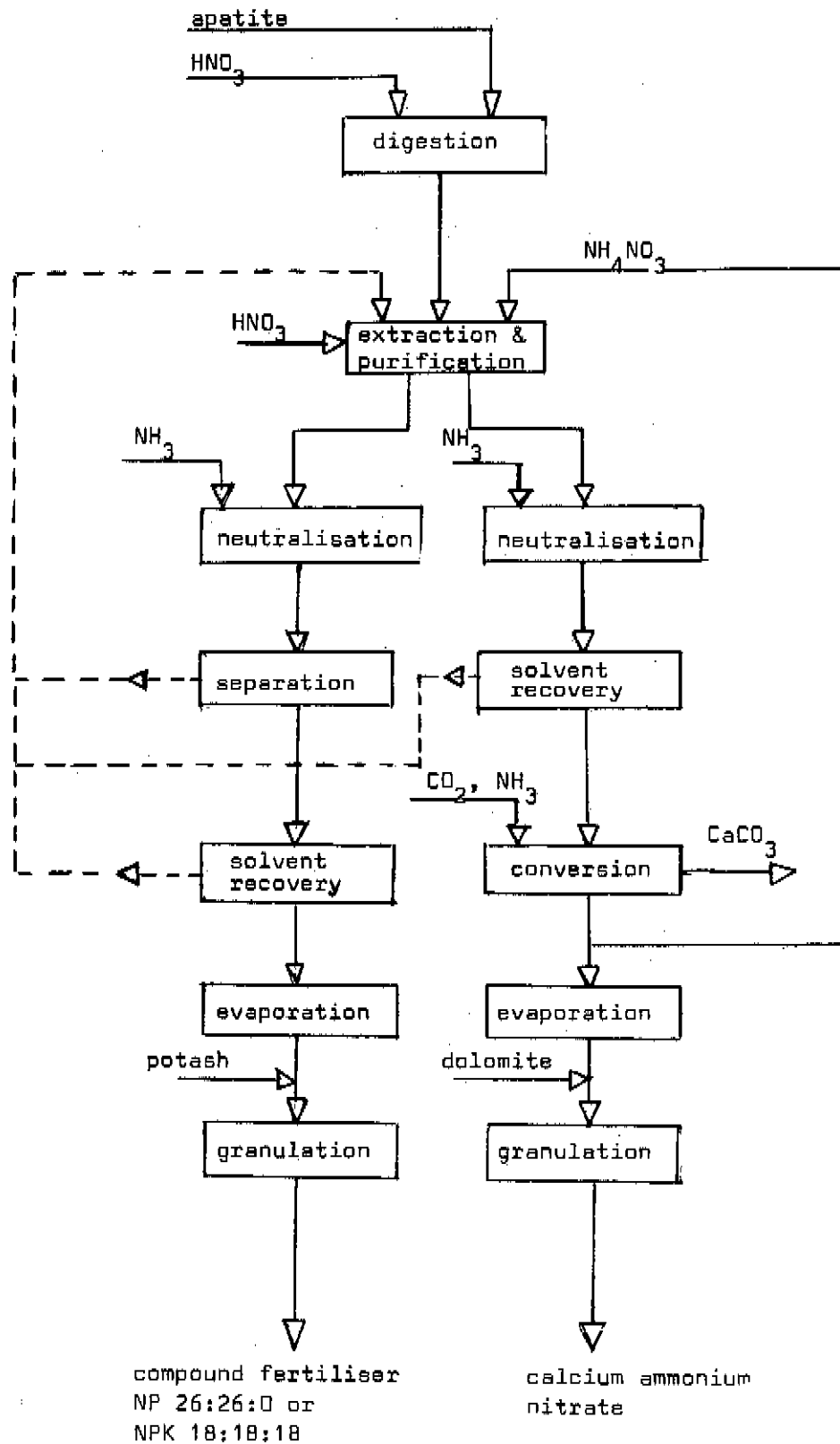


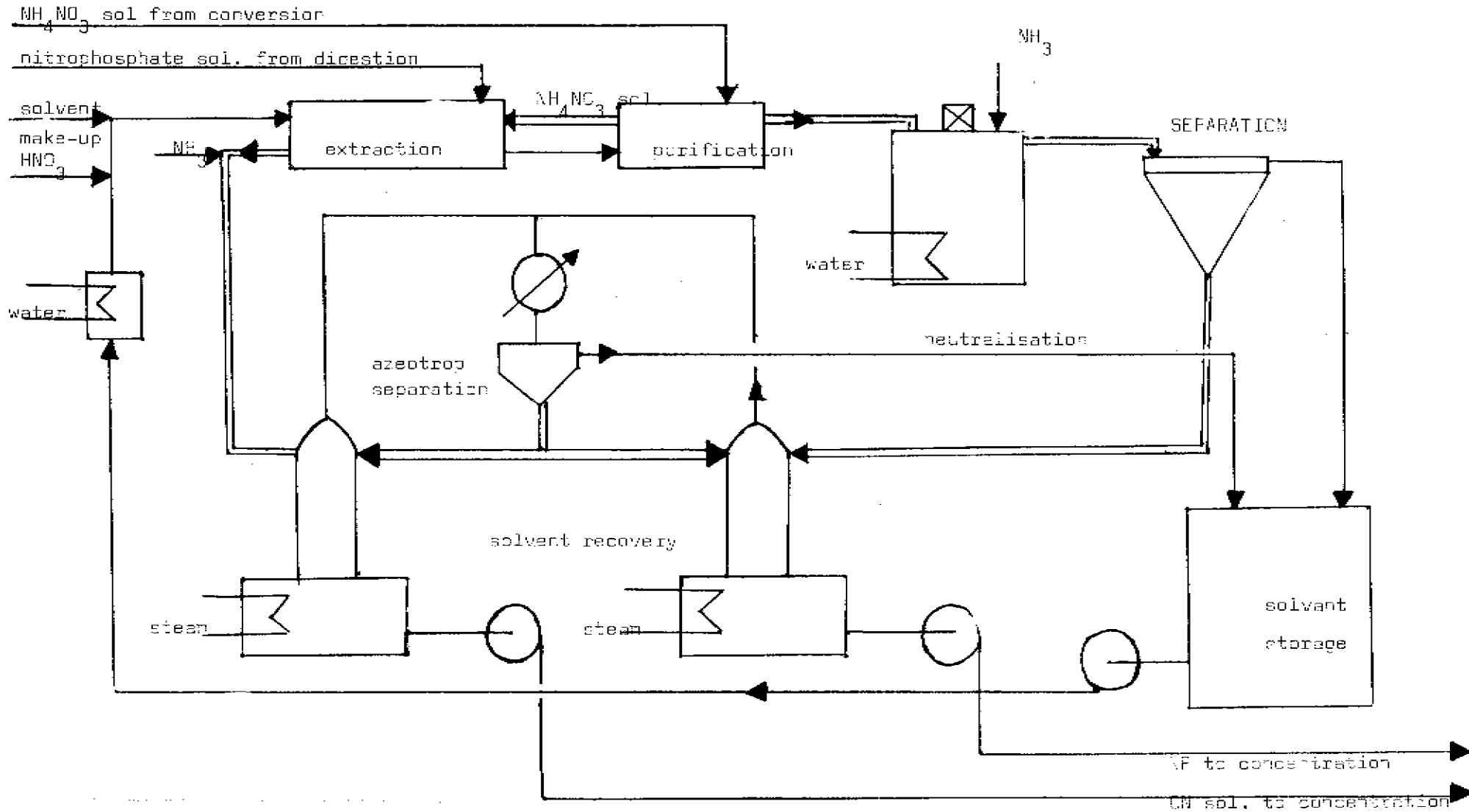
Figure 4

THE TYPPI OY PROCESS FOR COMPOUND AND NITROGEN FERTILISERS

PTF/70/15

Figure 5

THE TYPPI OY FERTILISER PROCESS



PTF/70/15

Figure 5

THE TYPICAL PROCESS FOR COMPOUND FERTILISERS. SOLVENT FLOW

